US 20030169759A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2003/0169759 A1

Asai (43) Pub. Date: Sep. 11, 2003

(54) COMMUNICATION DEVICE FOR PROCESSING DATA RECEIVED FROM NETWORK

(75) Inventor: Takashi Asai, Hyogo (JP)

Correspondence Address:
McDERMOTT, WILL & EMERY
600 13th Street, N.W.
Washington, DC 20005-3096 (US)

(73) Assignee: MITSUBISHI DENKI KABUSHIKI KAISHA

(21) Appl. No.: 10/323,977

(22) Filed: Dec. 20, 2002

(30) Foreign Application Priority Data

Mar. 7, 2002 (JP) ..... 2002-061841(P)

Publication Classification

(51) Int. Cl.[7] H04L 12/54

(52) U.S. Cl. 370/429; 370/395.52

(57) ABSTRACT

A PDA includes: an Ethernet controller which controls transmission and reception of data for a network; a buffer of a communication driver and a receiving window which store the received data; a circuit which transfers the data stored in the buffer of the driver to a designated buffer in response to a request to store the data in the designated buffer, the request issued before preset time passes since the data has been stored in the buffer of the communication driver; a circuit which transfers the data stored in the buffer of the driver to the receiving window when the preset time passes since the data has been stored in the buffer of the driver; and a circuit which transfers the data stored in the receiving window to the designated buffer in response to the request to store the data in the designated buffer.

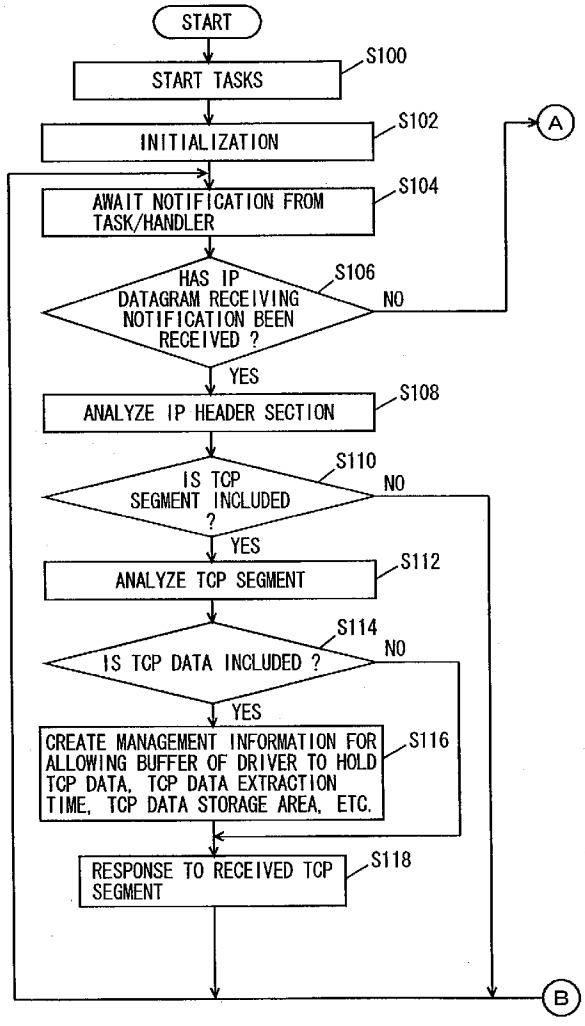


FIG. 1

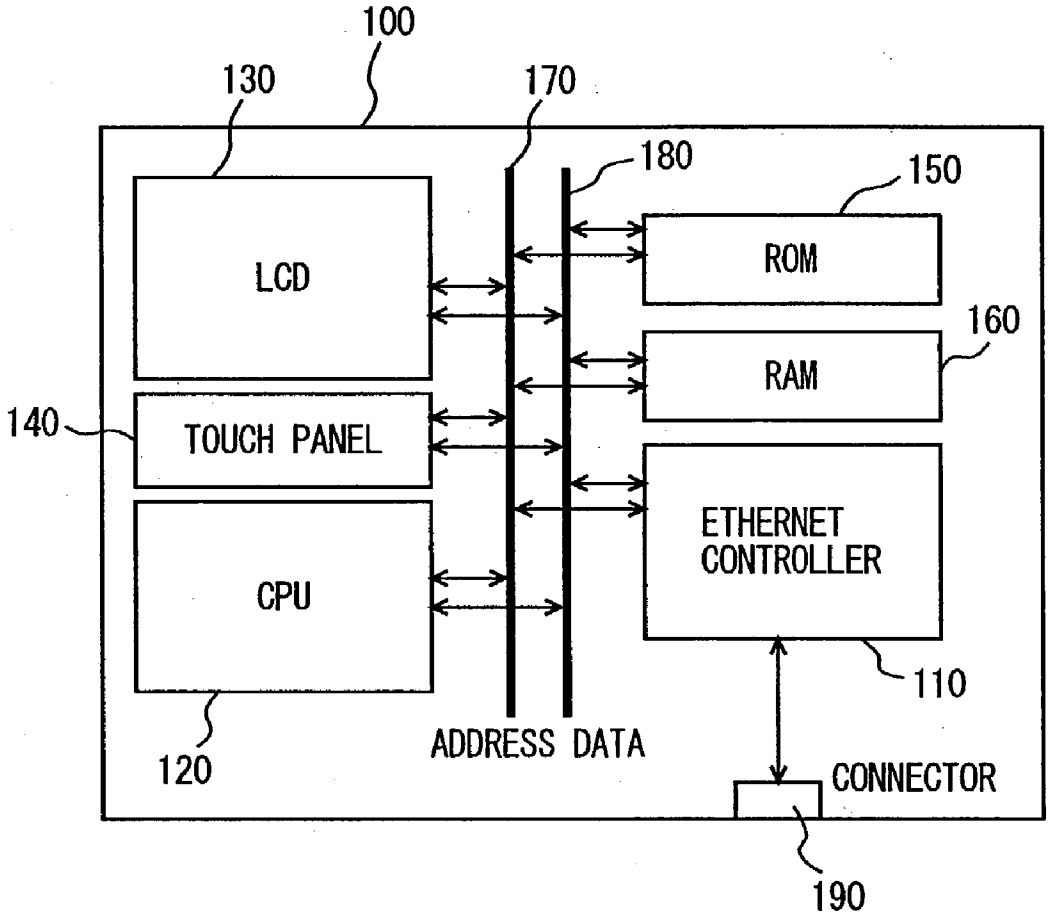

100
130
170
180
150
LCD
ROM
160
RAM
140
TOUCH PANEL
ETHERNET CONTROLLER
CPU
110
120
ADDRESS DATA
CONNECTOR
190

FIG. 2

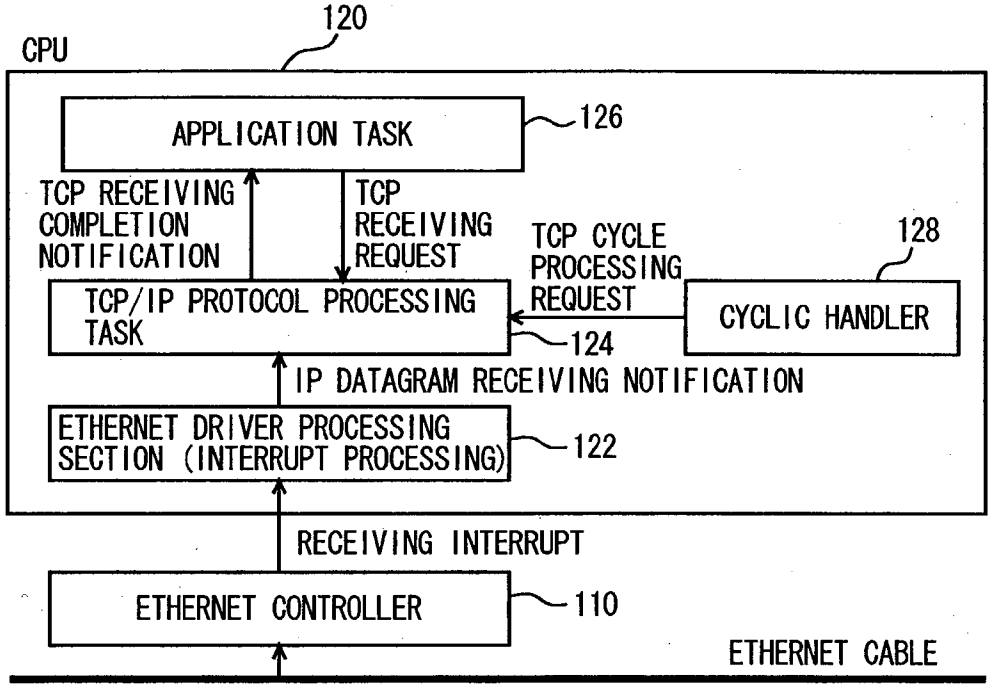

120
CPU
APPLICATION TASK
126
TCP RECEIVING COMPLETION NOTIFICATION
TCP RECEIVING REQUEST
TCP CYCLE PROCESSING REQUEST
128
TCP/IP PROTOCOL PROCESSING TASK
124
CYCLIC HANDLER
IP DATAGRAM RECEIVING NOTIFICATION
ETHERNET DRIVER PROCESSING SECTION (INTERRUPT PROCESSING)
122
RECEIVING INTERRUPT
ETHERNET CONTROLLER
110
ETHERNET CABLE

FIG. 3

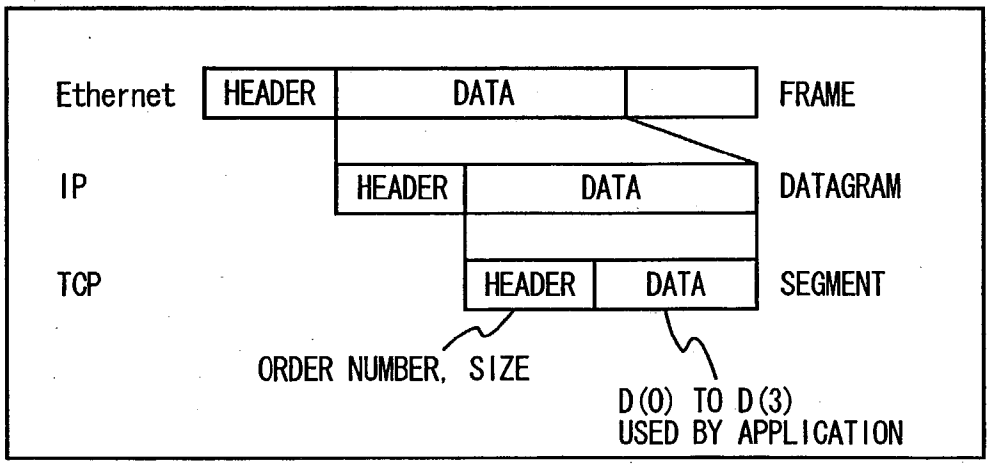

Ethernet
HEADER
DATA
FRAME
IP
HEADER
DATA
DATAGRAM
TCP
HEADER
DATA
SEGMENT
ORDER NUMBER, SIZE
D(0) TO D(3)
USED BY APPLICATION

FIG. 4

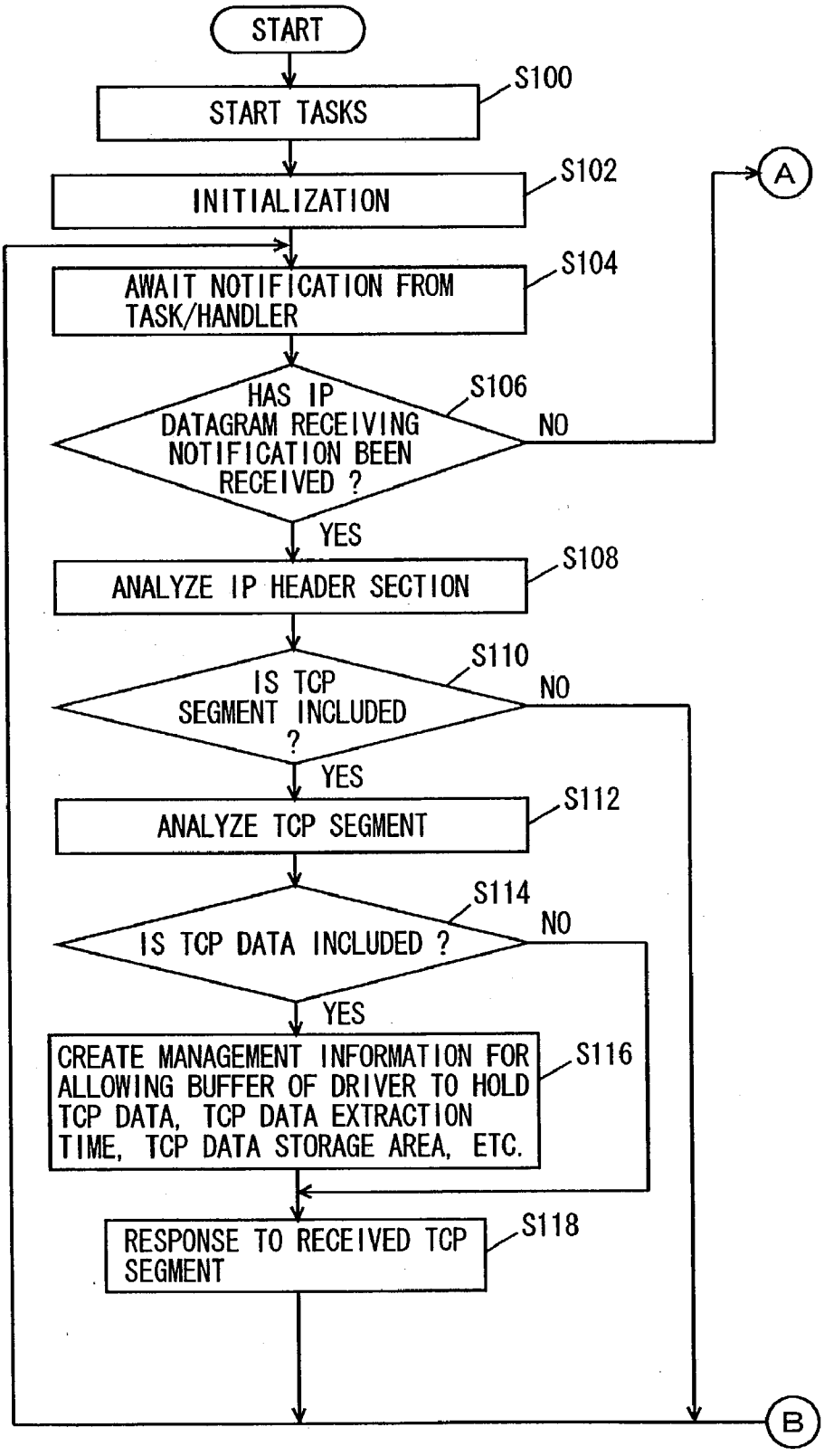

START
START TASKS
S100
INITIALIZATION
S102
A
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
RESPONSE TO RECEIVED TCP SEGMENT
S118
B

FIG. 5

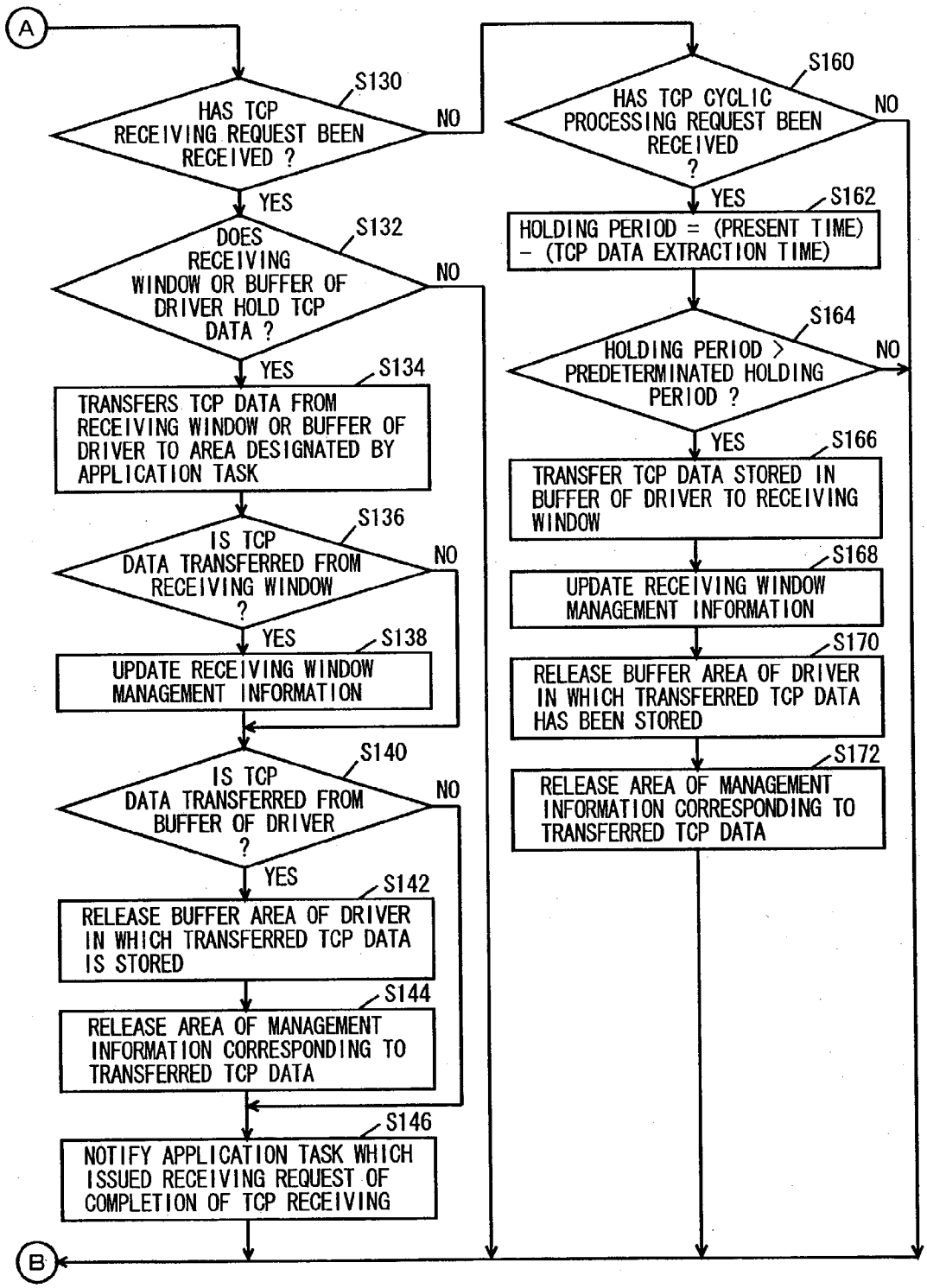

A
S130
HAS TCP RECEIVING REQUEST BEEN RECEIVED ?
NO
YES
S132
DOES RECEIVING WINDOW OR BUFFER OF DRIVER HOLD TCP DATA ?
NO
YES
S134
TRANSFERS TCP DATA FROM RECEIVING WINDOW OR BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S136
IS TCP DATA TRANSFERRED FROM RECEIVING WINDOW ?
NO
YES
S138
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S140
IS TCP DATA TRANSFERRED FROM BUFFER OF DRIVER ?
NO
YES
S142
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA IS STORED
S144
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA
S146
NOTIFY APPLICATION TASK WHICH ISSUED RECEIVING REQUEST OF COMPLETION OF TCP RECEIVING
B
S160
HAS TCP CYCLIC PROCESSING REQUEST BEEN RECEIVED ?
NO
YES
S162
HOLDING PERIOD = (PRESENT TIME) - (TCP DATA EXTRACTION TIME)
S164
HOLDING PERIOD > PREDETERMINATED HOLDING PERIOD ?
NO
YES
S166
TRANSFER TCP DATA STORED IN BUFFER OF DRIVER TO RECEIVING WINDOW
S168
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S170
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S172
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA

FIG. 6

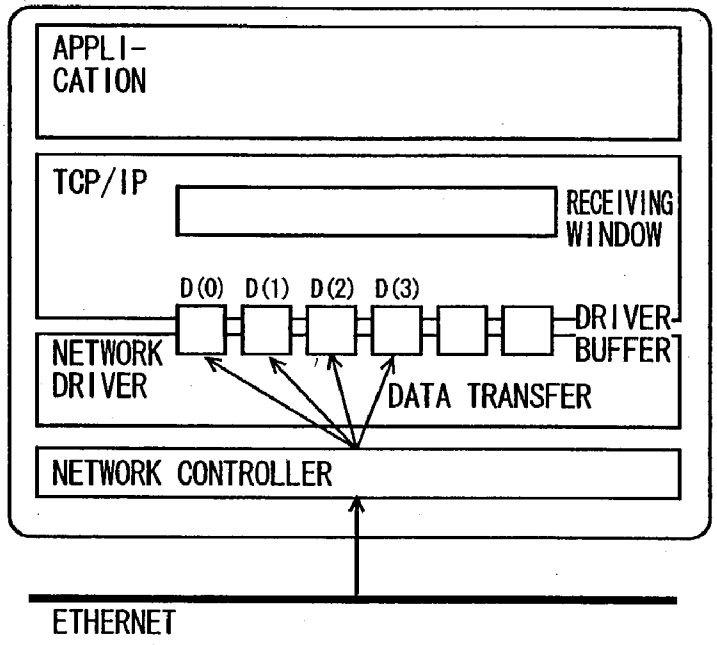

APPLI-
CATION
TCP/IP
RECEIVING
WINDOW
D(0) D(1) D(2) D(3)
DRIVER-
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 7

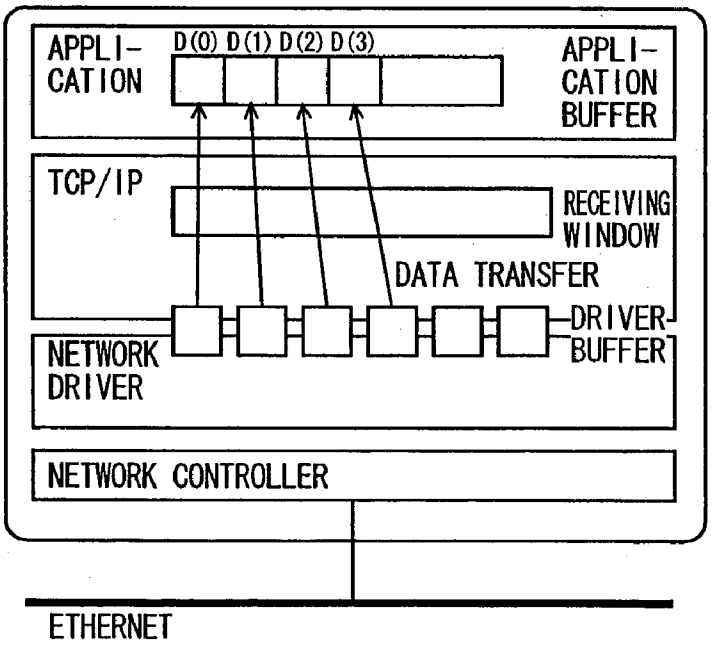

APPLI-
CATION
D(0) D(1) D(2) D(3)
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
DATA TRANSFER
DRIVER-
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 8

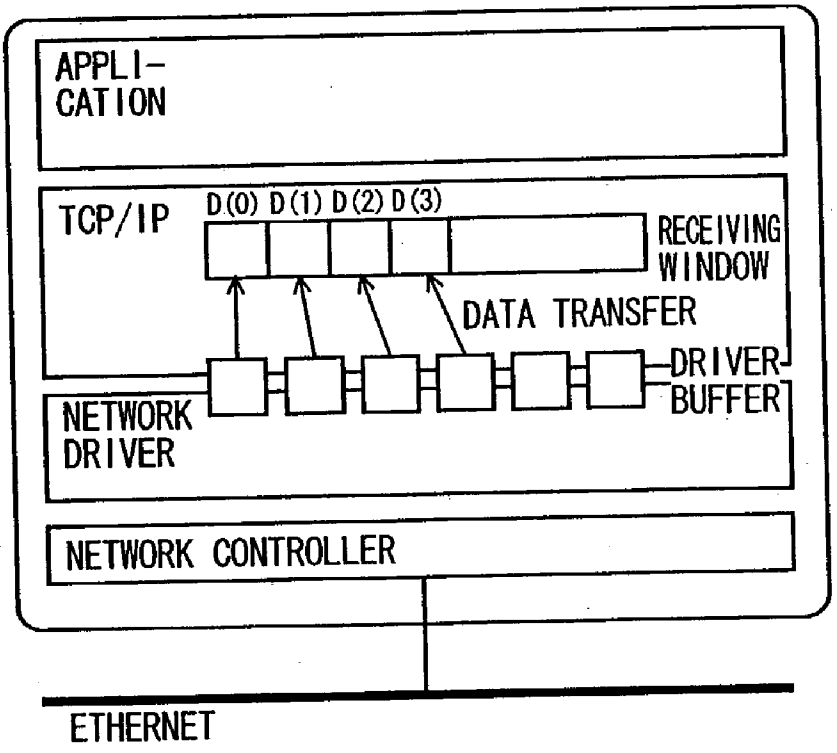

APPLI-
CATION
TCP/IP
D(0) D(1) D(2) D(3)
RECEIVING
WINDOW
DATA TRANSFER
DRIVER-
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 9

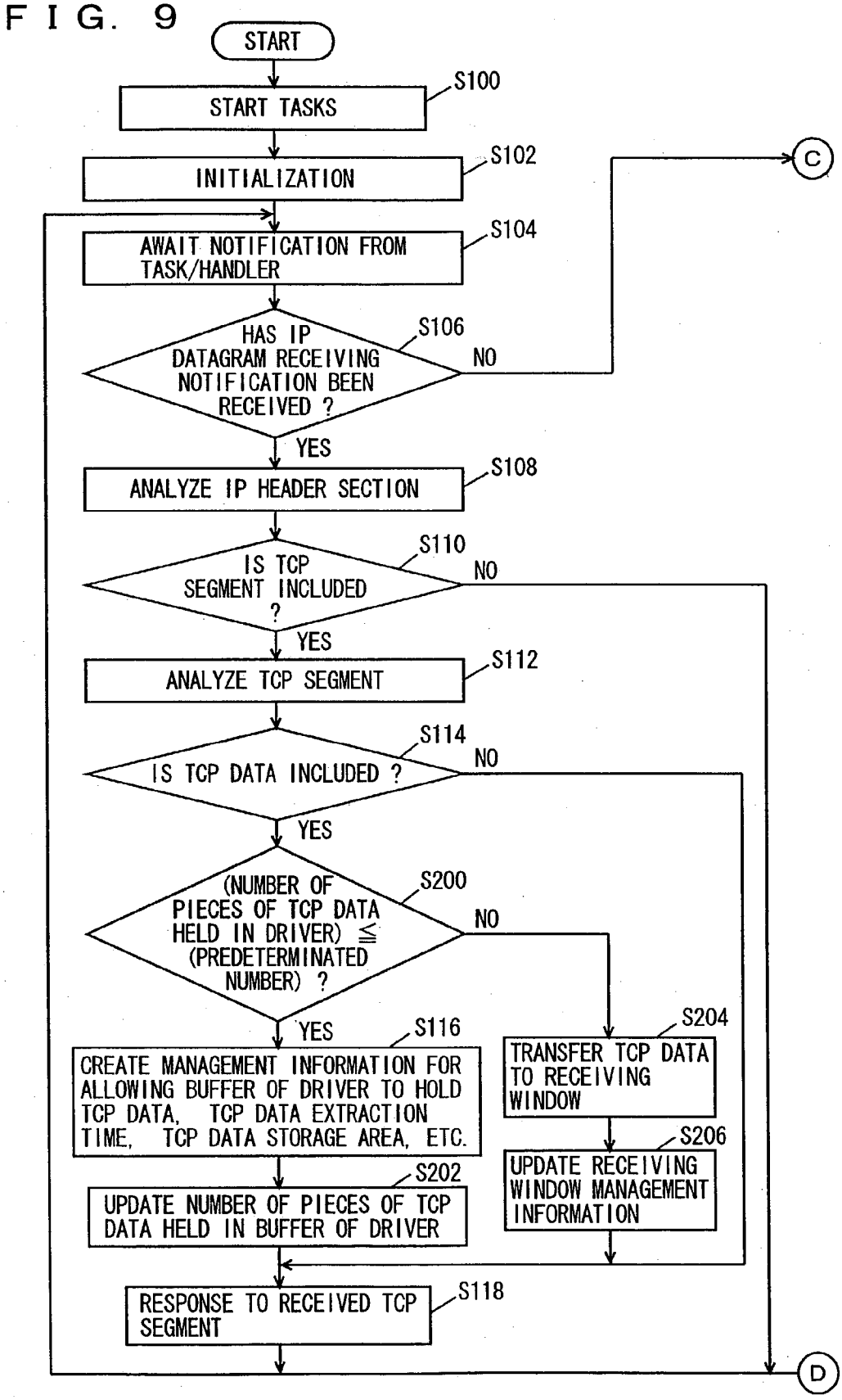

START
START TASKS
S100
INITIALIZATION
S102
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
S200
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S202
TRANSFER TCP DATA TO RECEIVING WINDOW
S204
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S206
RESPONSE TO RECEIVED TCP SEGMENT
S118
C
D

FIG. 10

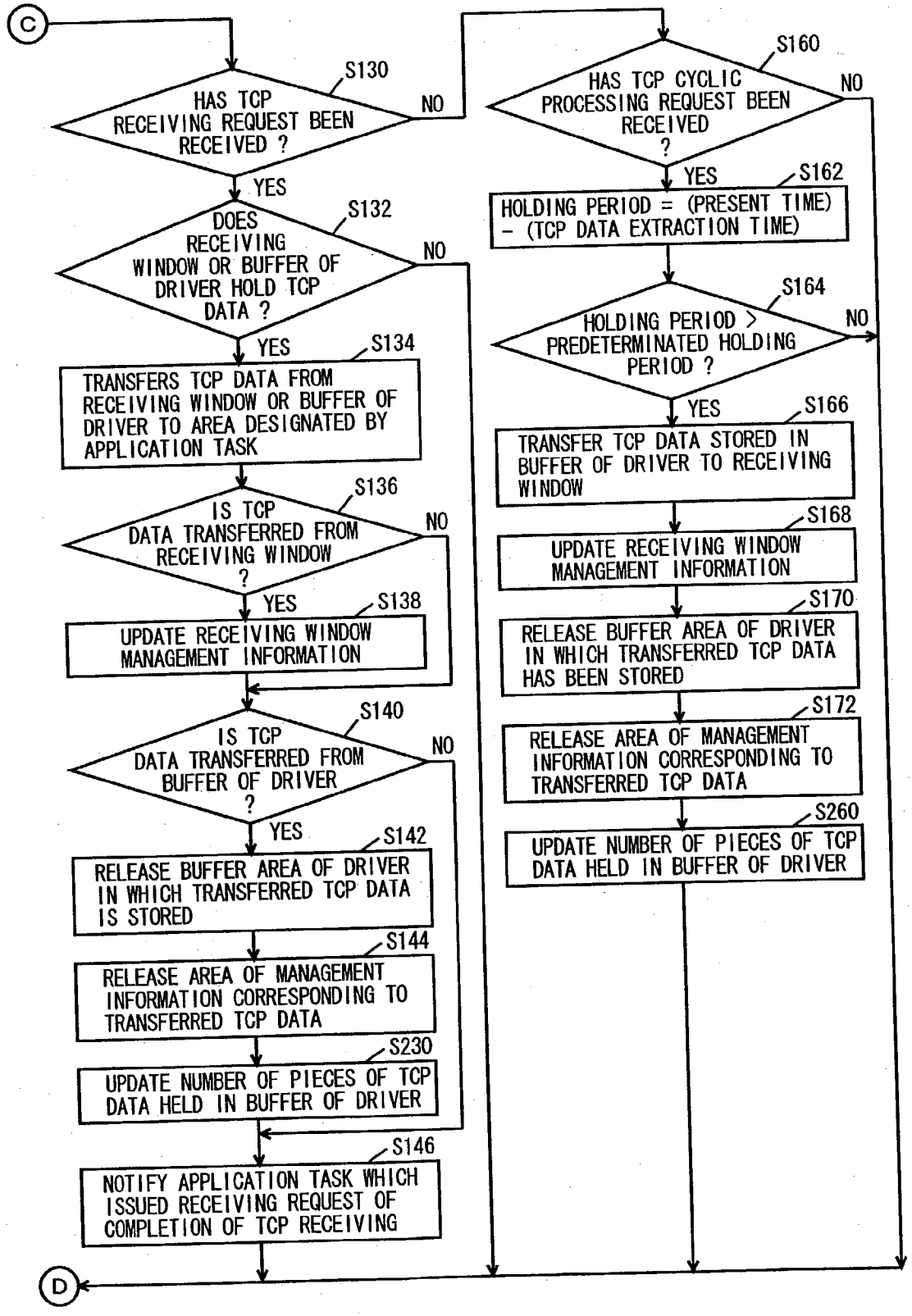

C
S130
HAS TCP RECEIVING REQUEST BEEN RECEIVED ?
NO
YES
S132
DOES RECEIVING WINDOW OR BUFFER OF DRIVER HOLD TCP DATA ?
NO
YES
S134
TRANSFERS TCP DATA FROM RECEIVING WINDOW OR BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S136
IS TCP DATA TRANSFERRED FROM RECEIVING WINDOW ?
NO
YES
S138
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S140
IS TCP DATA TRANSFERRED FROM BUFFER OF DRIVER ?
NO
YES
S142
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA IS STORED
S144
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA
S230
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S146
NOTIFY APPLICATION TASK WHICH ISSUED RECEIVING REQUEST OF COMPLETION OF TCP RECEIVING
S160
HAS TCP CYCLIC PROCESSING REQUEST BEEN RECEIVED ?
NO
YES
S162
HOLDING PERIOD = (PRESENT TIME) - (TCP DATA EXTRACTION TIME)
S164
HOLDING PERIOD > PREDETERMINATED HOLDING PERIOD ?
NO
YES
S166
TRANSFER TCP DATA STORED IN BUFFER OF DRIVER TO RECEIVING WINDOW
S168
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S170
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S172
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA
S260
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
D

FIG. 11

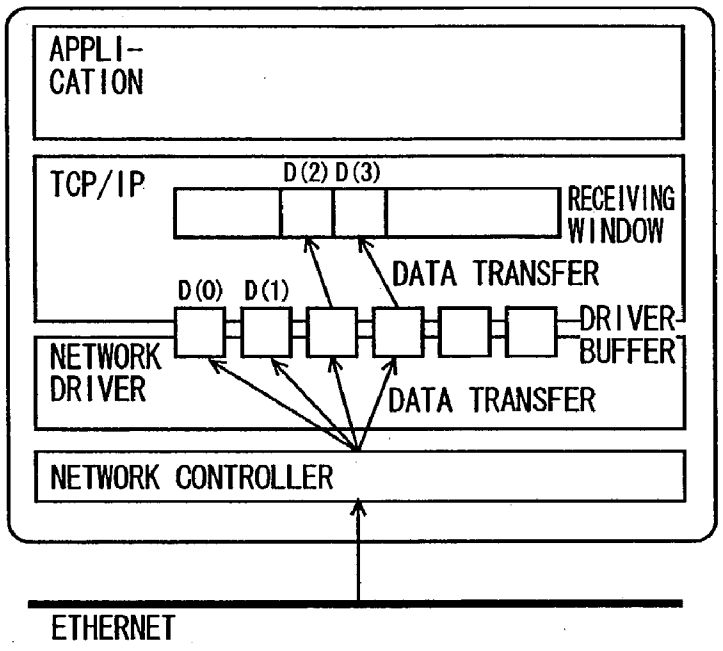

APPLI-
CATION
TCP/IP
D(2) D(3)
RECEIVING
WINDOW
DATA TRANSFER
D(0) D(1)
DRIVER
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 12

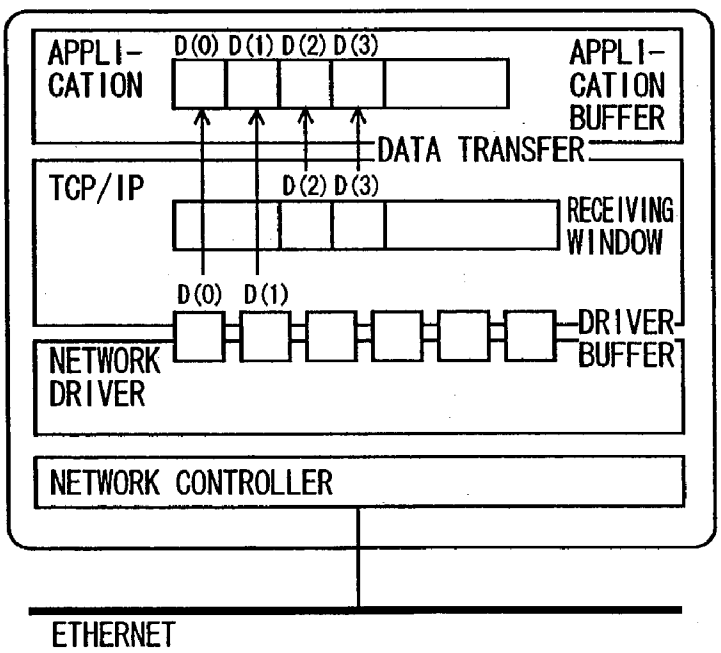

APPLI-
CATION
D(0) D(1) D(2) D(3)
APPLI-
CATION
BUFFER
DATA TRANSFER
TCP/IP
D(2) D(3)
RECEIVING
WINDOW
D(0) D(1)
DRIVER
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 13

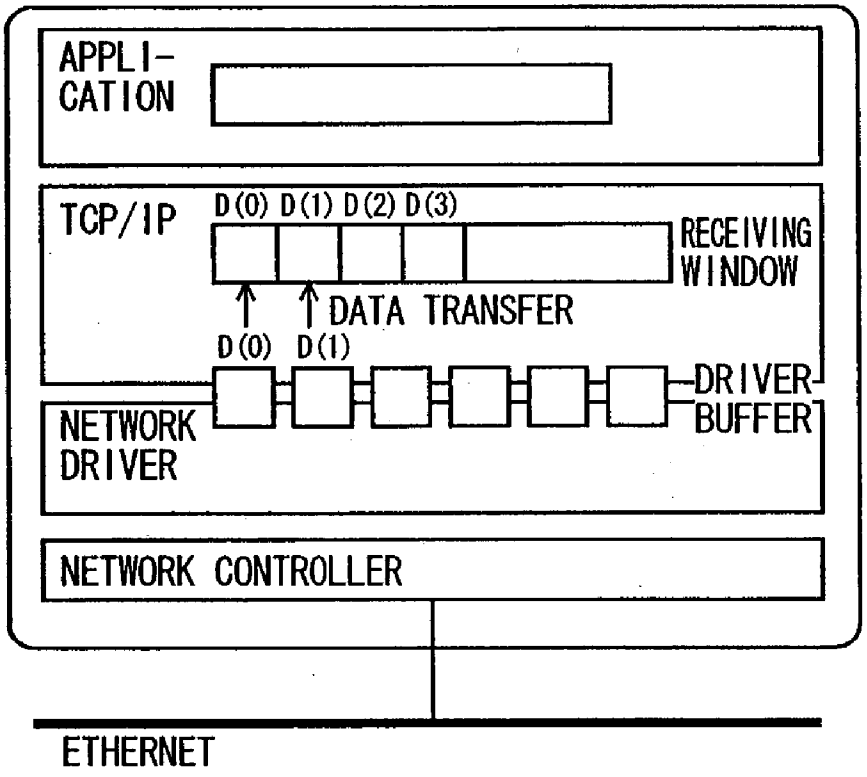

APPLI-
CATION
TCP/IP
D(0) D(1) D(2) D(3)
RECEIVING
WINDOW
DATA TRANSFER
D(0) D(1)
DRIVER
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 14

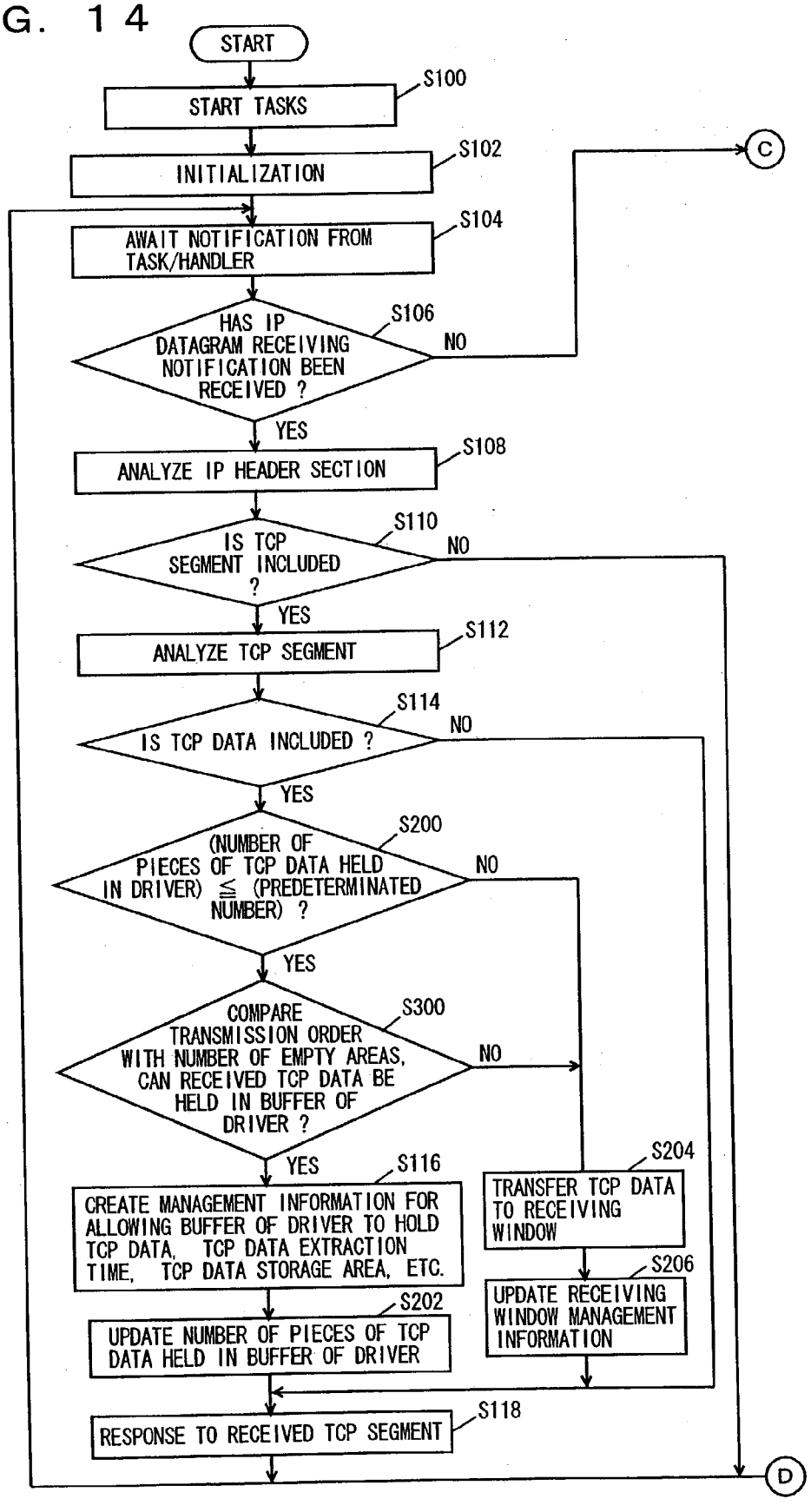

START
START TASKS
S100
INITIALIZATION
S102
C
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
S200
NO
YES
COMPARE TRANSMISSION ORDER WITH NUMBER OF EMPTY AREAS, CAN RECEIVED TCP DATA BE HELD IN BUFFER OF DRIVER ?
S300
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S202
TRANSFER TCP DATA TO RECEIVING WINDOW
S204
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S206
RESPONSE TO RECEIVED TCP SEGMENT
S118
D

FIG. 15

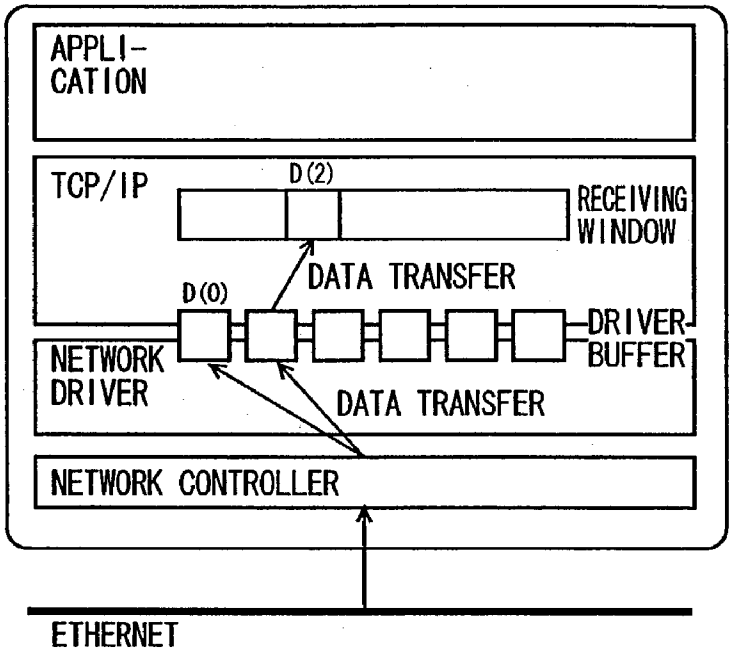

APPLI-
CATION
TCP/IP
D(2)
RECEIVING
WINDOW
DATA TRANSFER
D(0)
DRIVER-
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 16

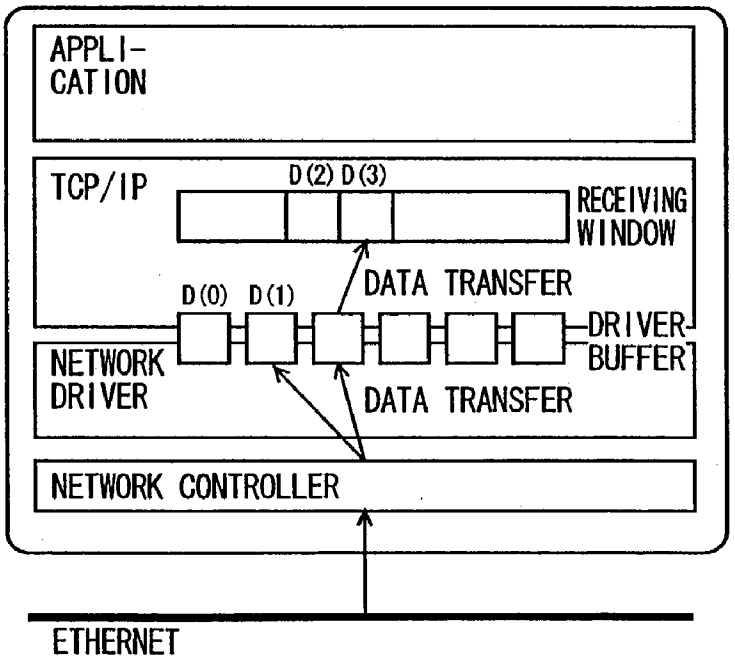

APPLI-
CATION
TCP/IP
D(2) D(3)
RECEIVING
WINDOW
DATA TRANSFER
D(0) D(1)
DRIVER-
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 17

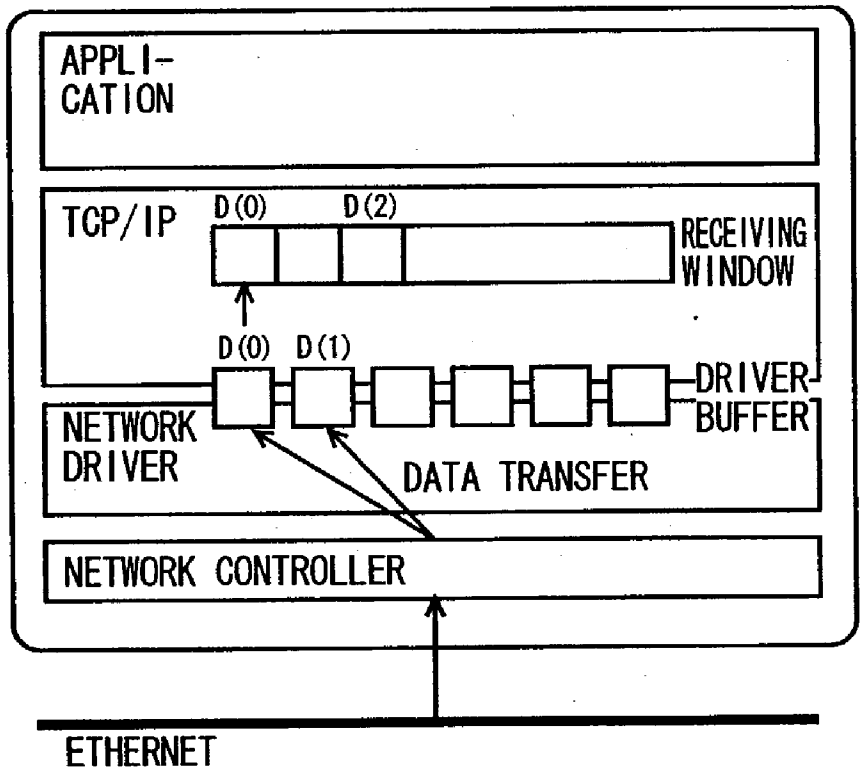

APPLI-
CATION
TCP/IP
D(0)
D(2)
RECEIVING
WINDOW
D(0)
D(1)
DRIVER-
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 18

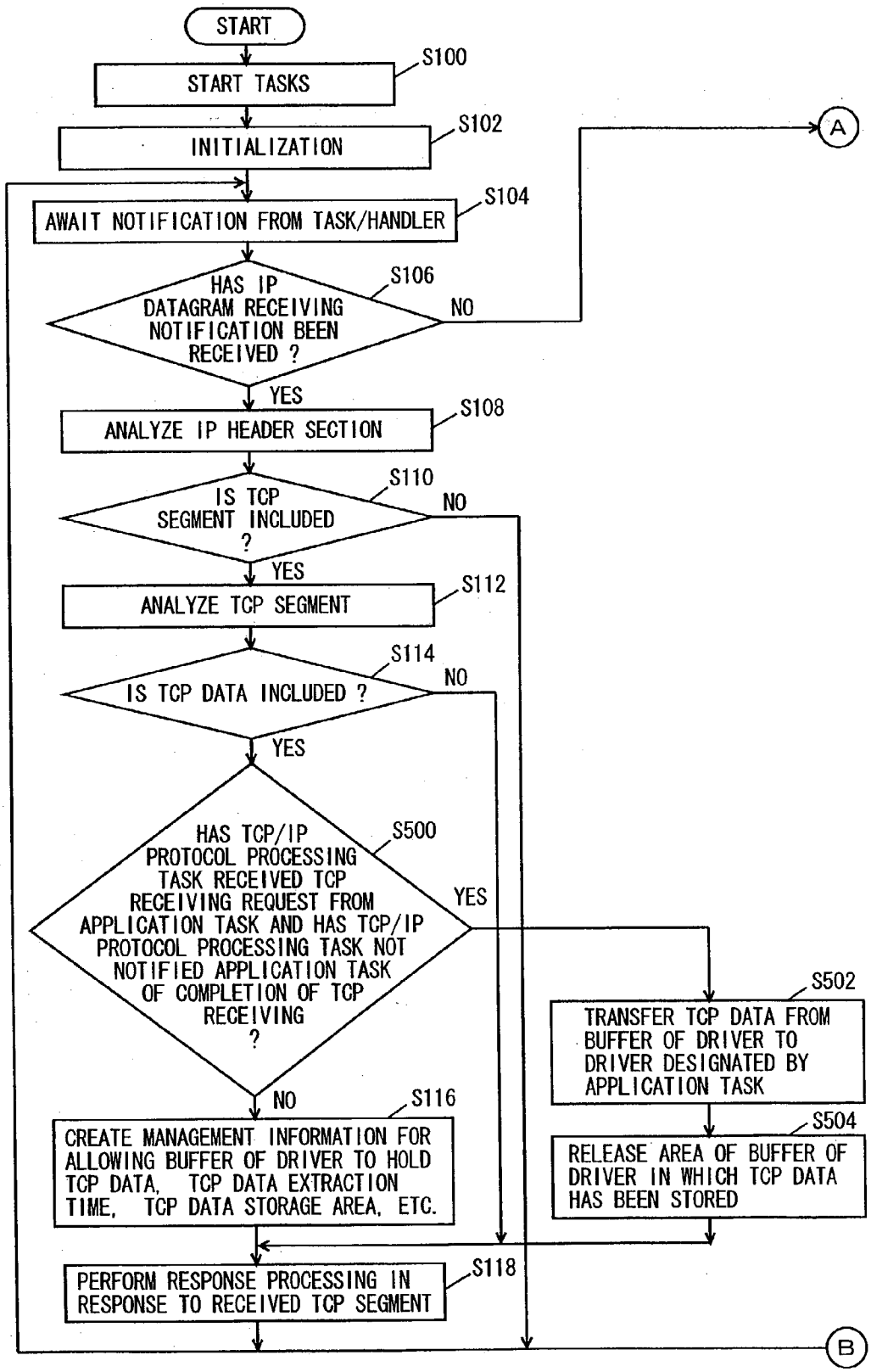

START
START TASKS
S100
INITIALIZATION
S102
A
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
HAS TCP/IP PROTOCOL PROCESSING TASK RECEIVED TCP RECEIVING REQUEST FROM APPLICATION TASK AND HAS TCP/IP PROTOCOL PROCESSING TASK NOT NOTIFIED APPLICATION TASK OF COMPLETION OF TCP RECEIVING ?
S500
YES
NO
S116
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S502
TRANSFER TCP DATA FROM BUFFER OF DRIVER TO DRIVER DESIGNATED BY APPLICATION TASK
S504
RELEASE AREA OF BUFFER OF DRIVER IN WHICH TCP DATA HAS BEEN STORED
PERFORM RESPONSE PROCESSING IN RESPONSE TO RECEIVED TCP SEGMENT
S118
B

FIG. 19

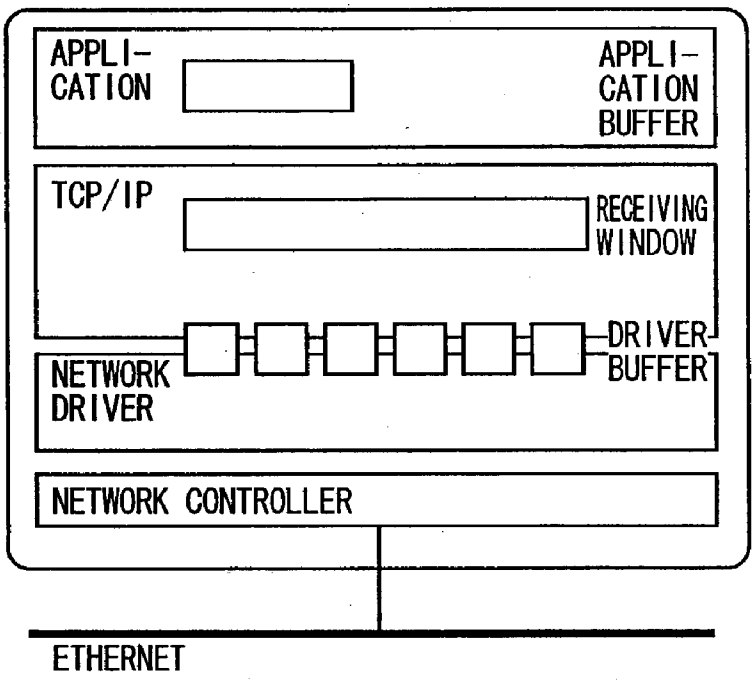

APPLI-
CATION
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
DRIVER
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 20

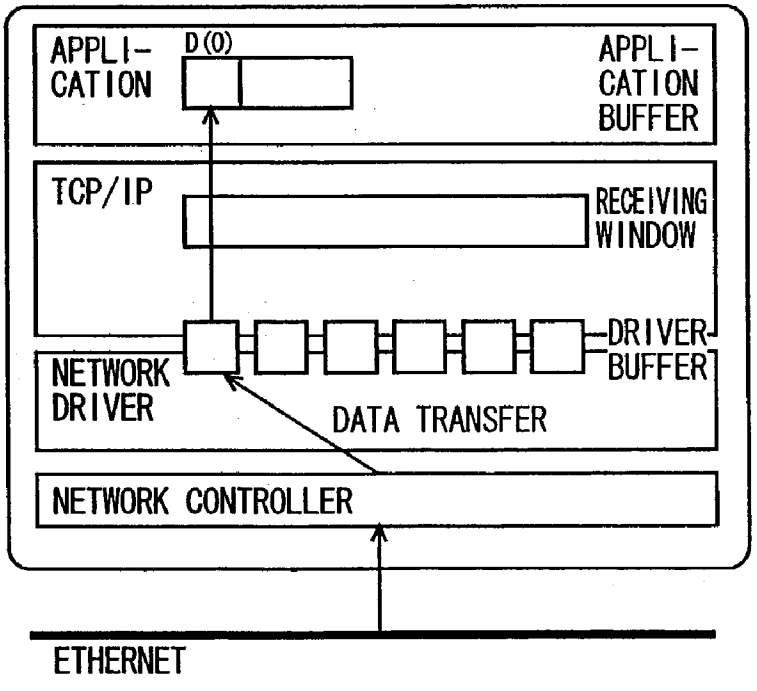

APPLI-
CATION
D(0)
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
DRIVER
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 21

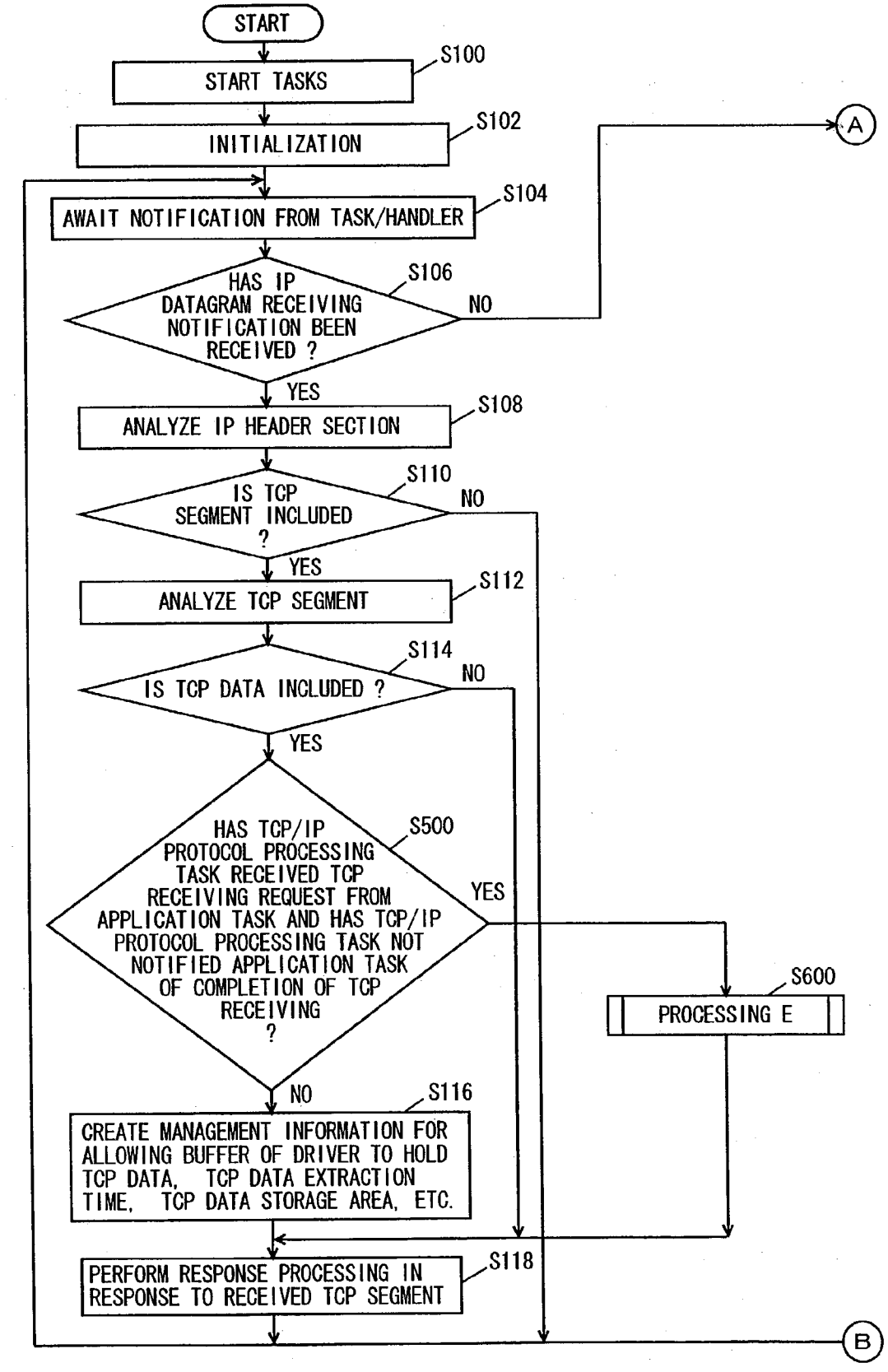

START
START TASKS
S100
INITIALIZATION
S102
A
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
HAS TCP/IP PROTOCOL PROCESSING TASK RECEIVED TCP RECEIVING REQUEST FROM APPLICATION TASK AND HAS TCP/IP PROTOCOL PROCESSING TASK NOT NOTIFIED APPLICATION TASK OF COMPLETION OF TCP RECEIVING ?
S500
YES
S600
PROCESSING E
NO
S116
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
PERFORM RESPONSE PROCESSING IN RESPONSE TO RECEIVED TCP SEGMENT
S118
B

FIG. 22

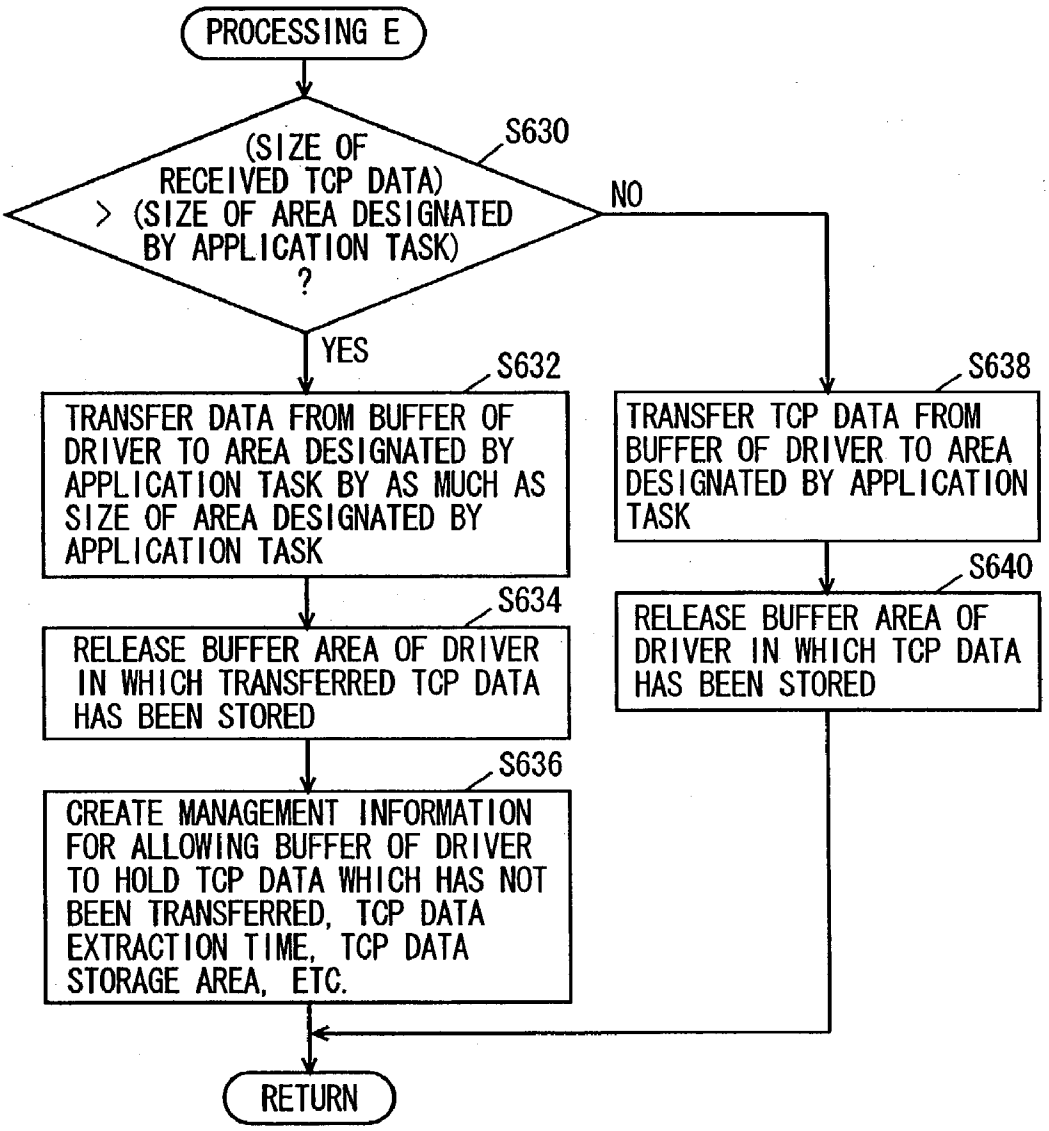

PROCESSING E
(SIZE OF RECEIVED TCP DATA) > (SIZE OF AREA DESIGNATED BY APPLICATION TASK) ?
S630
NO
YES
S632
TRANSFER DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK BY AS MUCH AS SIZE OF AREA DESIGNATED BY APPLICATION TASK
S634
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S636
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA WHICH HAS NOT BEEN TRANSFERRED, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S638
TRANSFER TCP DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S640
RELEASE BUFFER AREA OF DRIVER IN WHICH TCP DATA HAS BEEN STORED
RETURN

FIG. 23

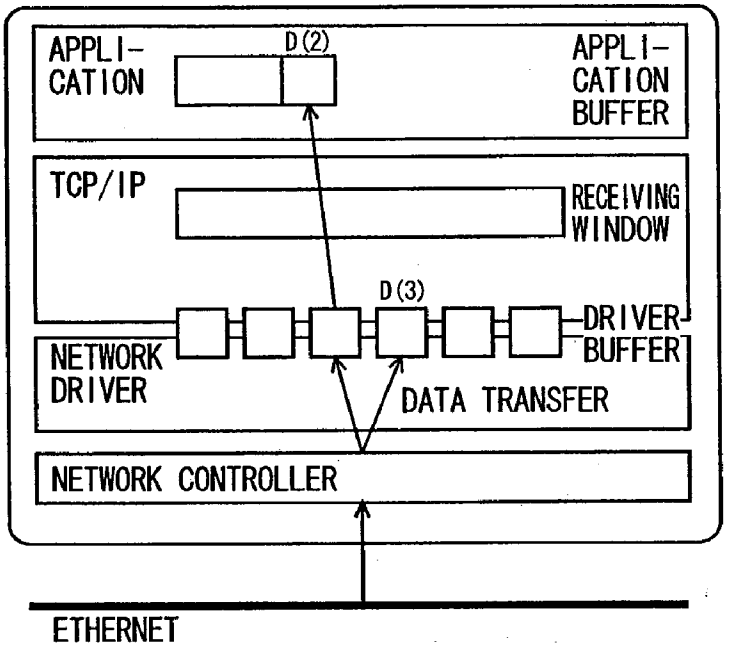

APPLI-
CATION
D(2)
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
D(3)
DRIVER
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 24

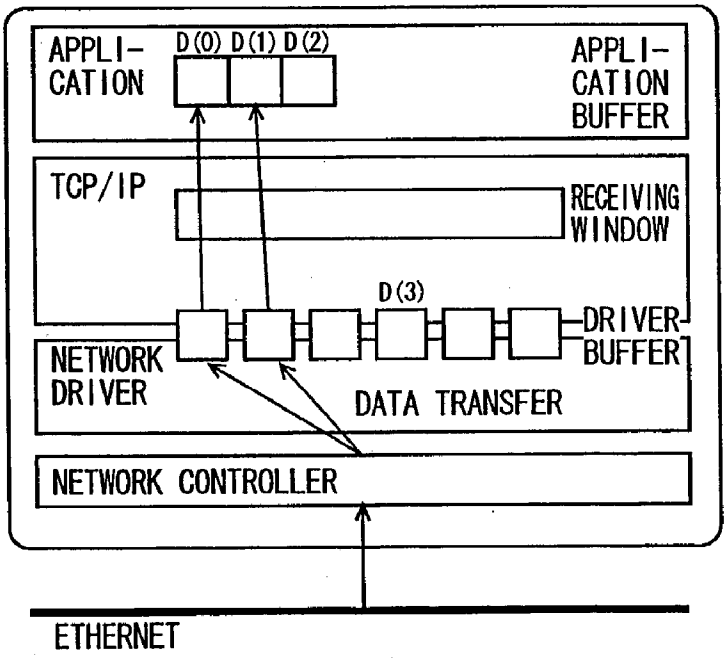

APPLI-
CATION
D(0) D(1) D(2)
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
D(3)
DRIVER
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 25

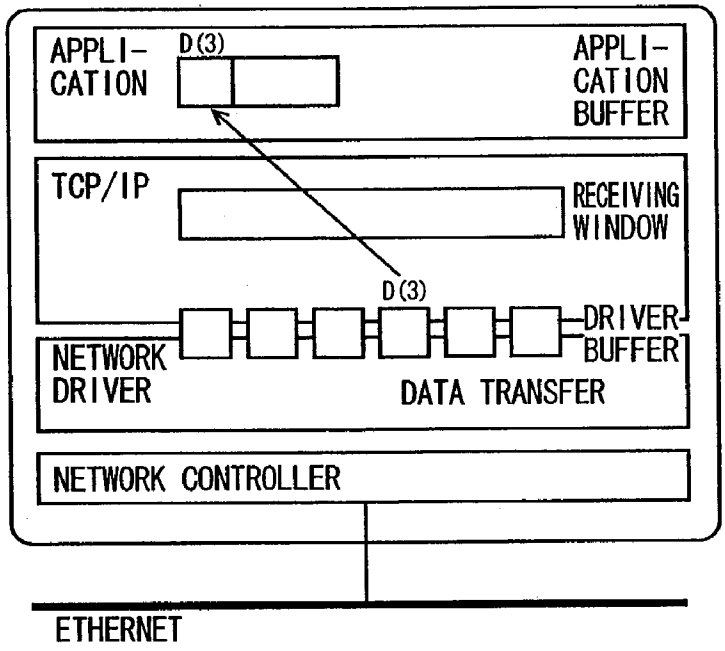

APPLI-
CATION
D(3)
APPLI-
CATION
BUFFER
TCP/IP
RECEIVING
WINDOW
D(3)
DRIVER
BUFFER
NETWORK
DRIVER
DATA TRANSFER
NETWORK CONTROLLER
ETHERNET

FIG. 26

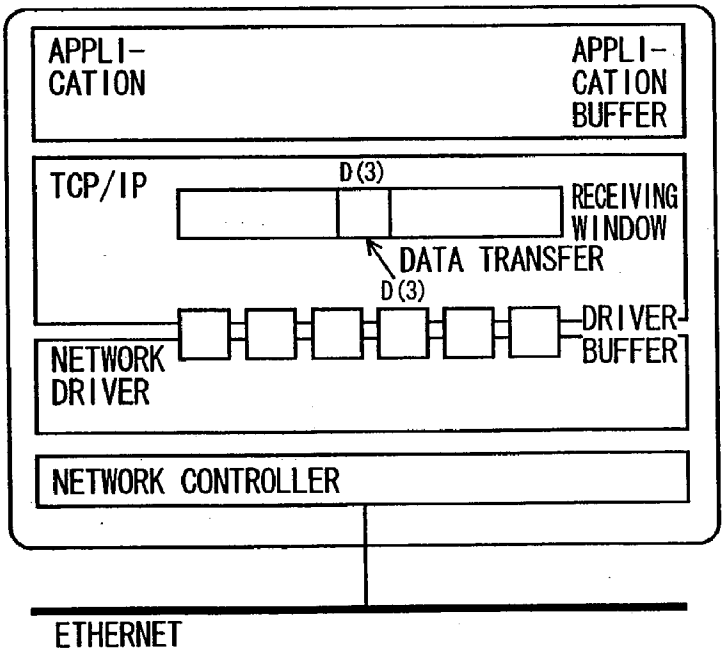

APPLI-
CATION
APPLI-
CATION
BUFFER
TCP/IP
D(3)
RECEIVING
WINDOW
DATA TRANSFER
D(3)
DRIVER
BUFFER
NETWORK
DRIVER
NETWORK CONTROLLER
ETHERNET

FIG. 27

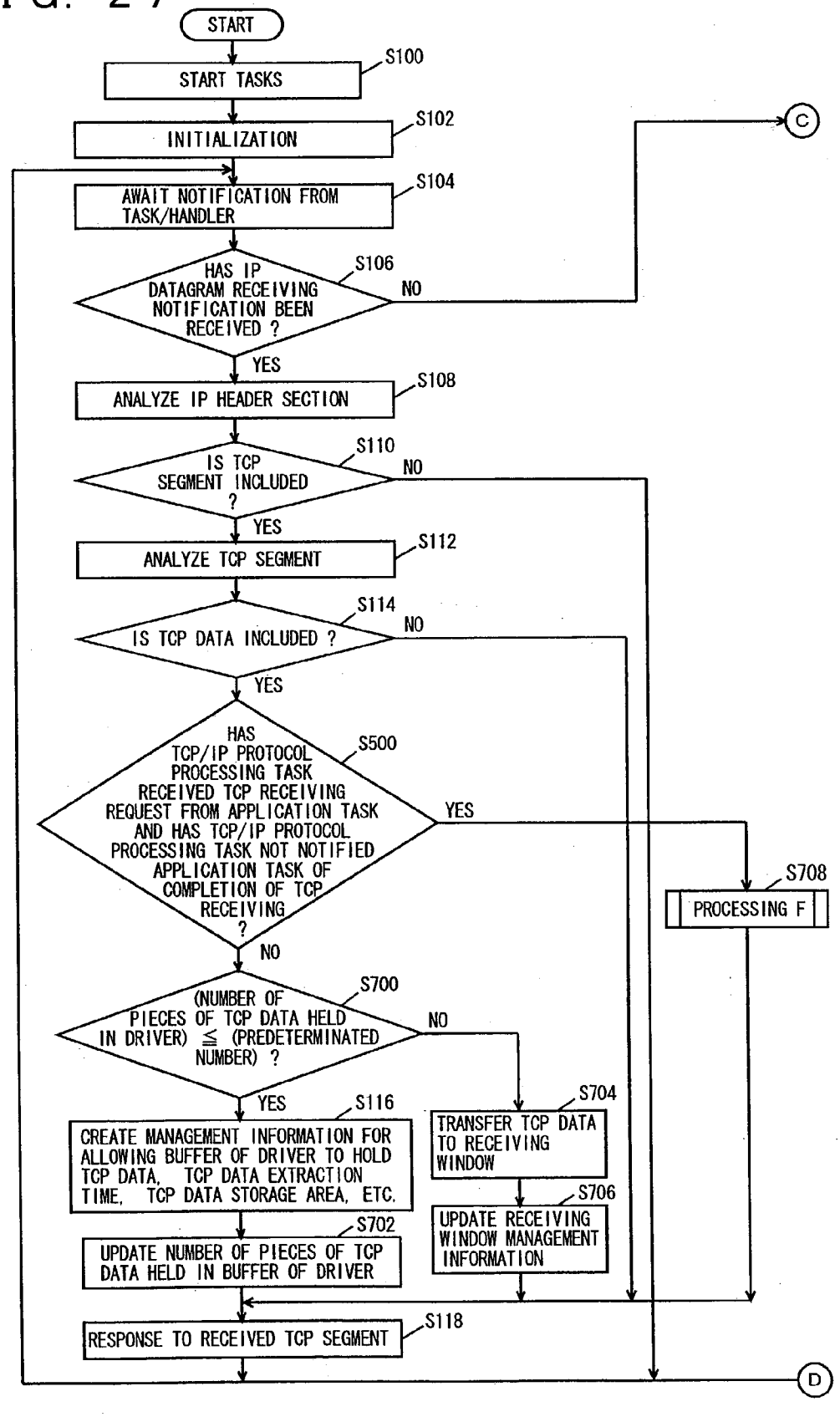

START
START TASKS
S100
INITIALIZATION
S102
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
HAS TCP/IP PROTOCOL PROCESSING TASK RECEIVED TCP RECEIVING REQUEST FROM APPLICATION TASK AND HAS TCP/IP PROTOCOL PROCESSING TASK NOT NOTIFIED APPLICATION TASK OF COMPLETION OF TCP RECEIVING ?
S500
YES
NO
PROCESSING F
S708
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
S700
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
TRANSFER TCP DATA TO RECEIVING WINDOW
S704
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S706
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S702
RESPONSE TO RECEIVED TCP SEGMENT
S118
C
D

FIG. 28

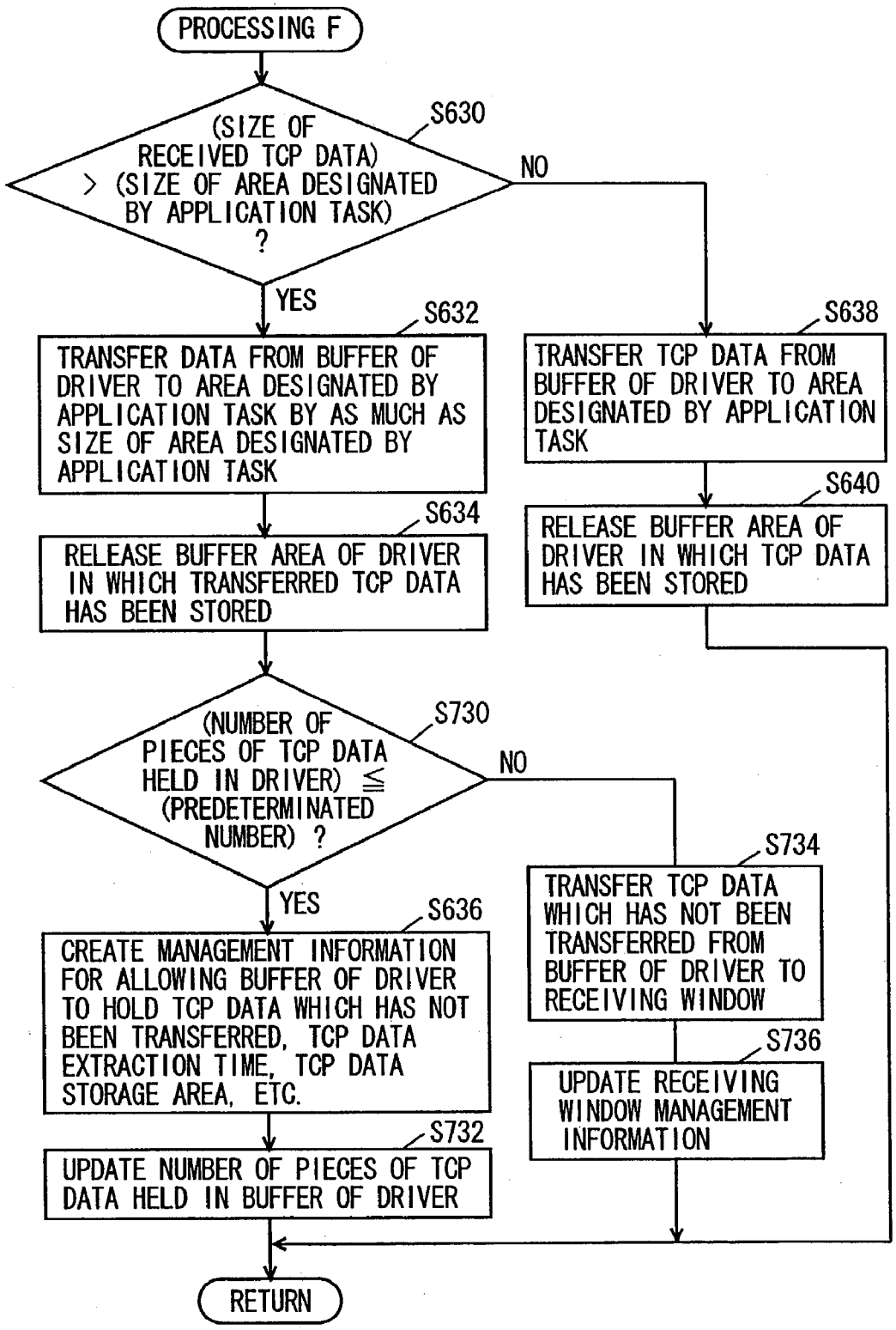

PROCESSING F
S630
(SIZE OF RECEIVED TCP DATA) > (SIZE OF AREA DESIGNATED BY APPLICATION TASK) ?
NO
YES
S632
TRANSFER DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK BY AS MUCH AS SIZE OF AREA DESIGNATED BY APPLICATION TASK
S634
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S638
TRANSFER TCP DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S640
RELEASE BUFFER AREA OF DRIVER IN WHICH TCP DATA HAS BEEN STORED
S730
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
NO
YES
S636
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA WHICH HAS NOT BEEN TRANSFERRED, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S732
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S734
TRANSFER TCP DATA WHICH HAS NOT BEEN TRANSFERRED FROM BUFFER OF DRIVER TO RECEIVING WINDOW
S736
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
RETURN

FIG. 29

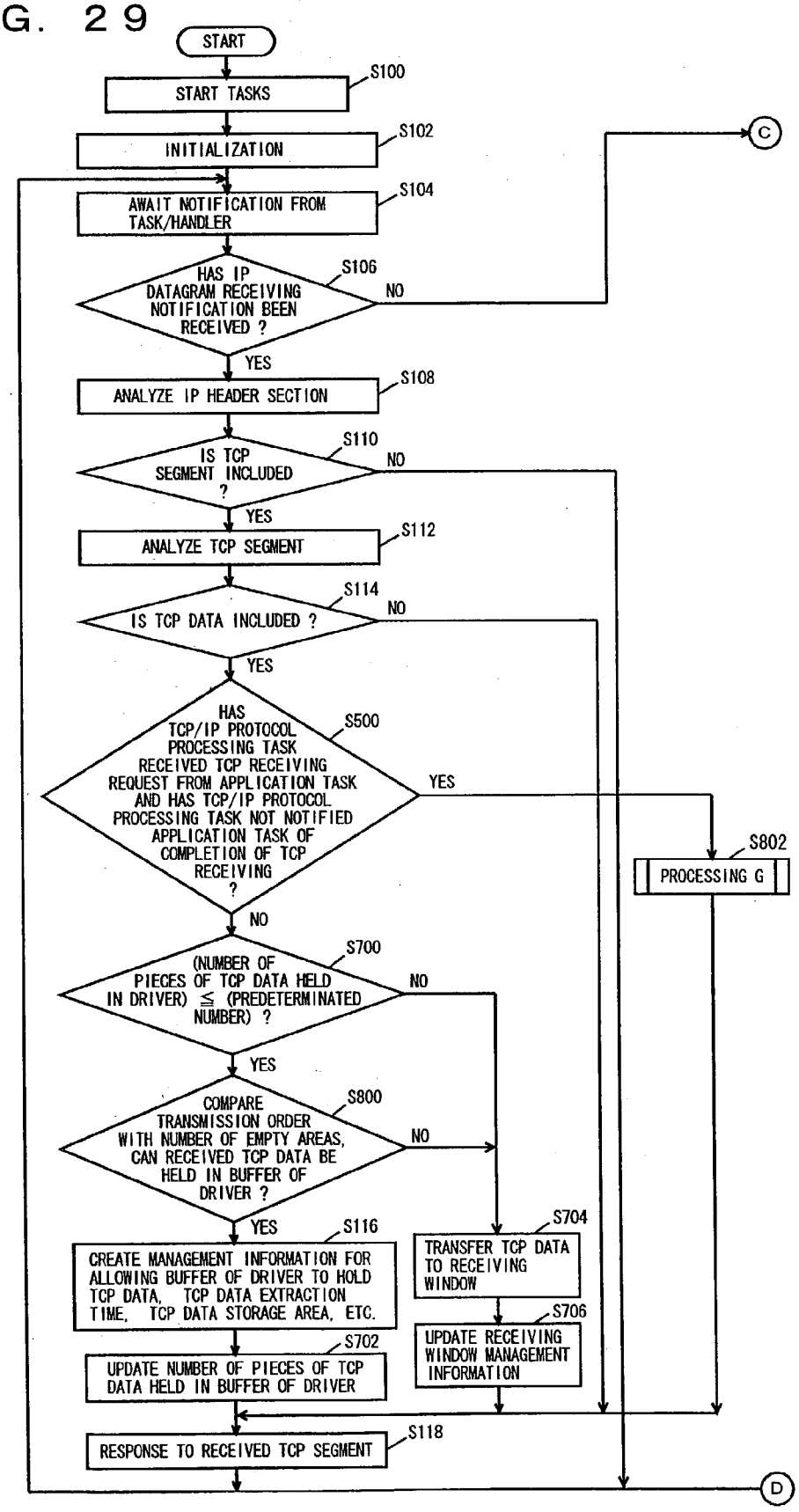

START
START TASKS
S100
INITIALIZATION
S102
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
HAS TCP/IP PROTOCOL PROCESSING TASK RECEIVED TCP RECEIVING REQUEST FROM APPLICATION TASK AND HAS TCP/IP PROTOCOL PROCESSING TASK NOT NOTIFIED APPLICATION TASK OF COMPLETION OF TCP RECEIVING ?
S500
YES
S802
PROCESSING G
NO
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
S700
NO
YES
COMPARE TRANSMISSION ORDER WITH NUMBER OF EMPTY AREAS, CAN RECEIVED TCP DATA BE HELD IN BUFFER OF DRIVER ?
S800
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
TRANSFER TCP DATA TO RECEIVING WINDOW
S704
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S706
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S702
RESPONSE TO RECEIVED TCP SEGMENT
S118
C
D

FIG. 30

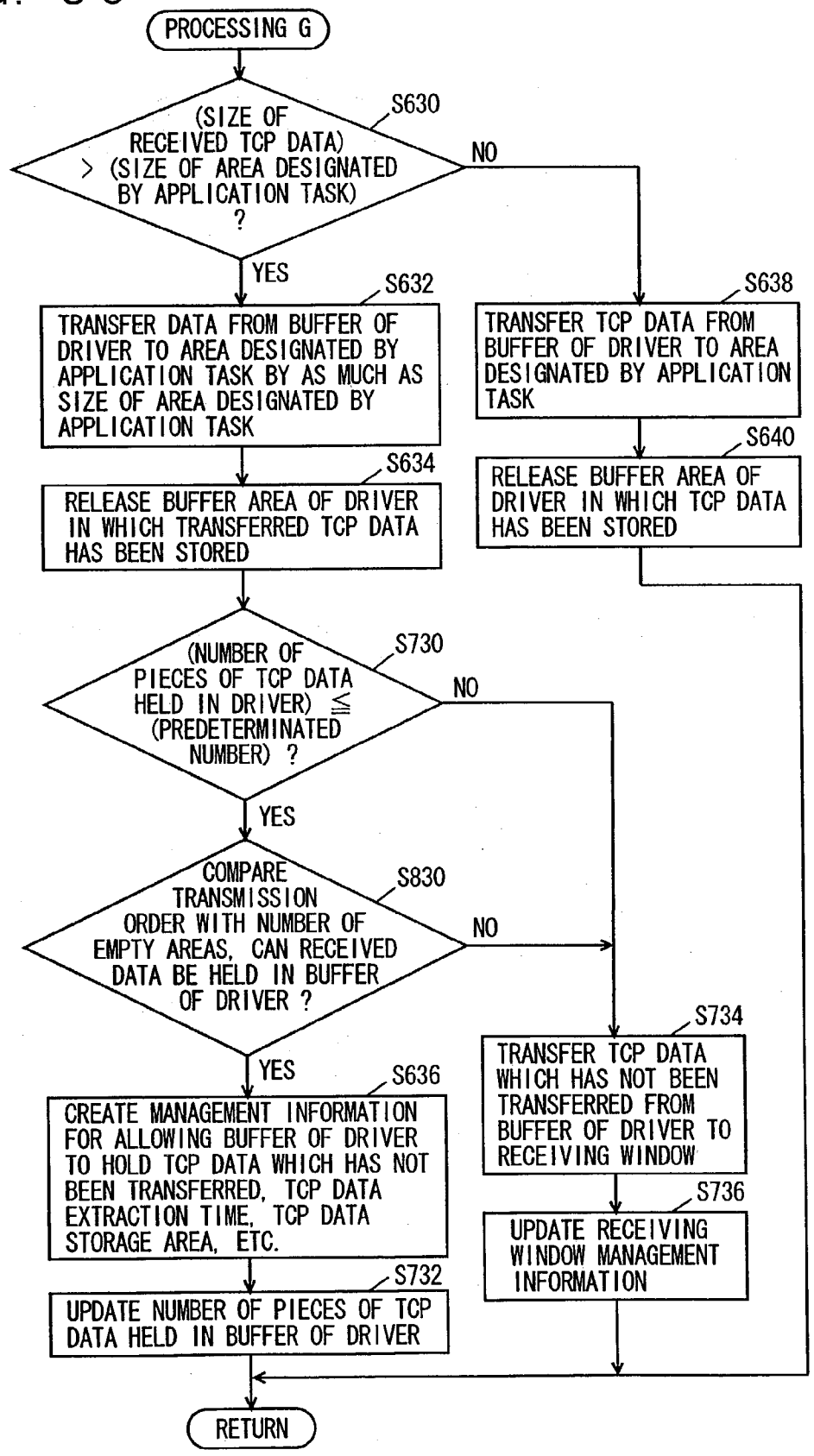

PROCESSING G
S630
(SIZE OF RECEIVED TCP DATA) > (SIZE OF AREA DESIGNATED BY APPLICATION TASK) ?
NO
YES
S632
TRANSFER DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK BY AS MUCH AS SIZE OF AREA DESIGNATED BY APPLICATION TASK
S634
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S638
TRANSFER TCP DATA FROM BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S640
RELEASE BUFFER AREA OF DRIVER IN WHICH TCP DATA HAS BEEN STORED
S730
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
NO
YES
S830
COMPARE TRANSMISSION ORDER WITH NUMBER OF EMPTY AREAS, CAN RECEIVED DATA BE HELD IN BUFFER OF DRIVER ?
NO
YES
S636
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA WHICH HAS NOT BEEN TRANSFERRED, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S732
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S734
TRANSFER TCP DATA WHICH HAS NOT BEEN TRANSFERRED FROM BUFFER OF DRIVER TO RECEIVING WINDOW
S736
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
RETURN

FIG. 31

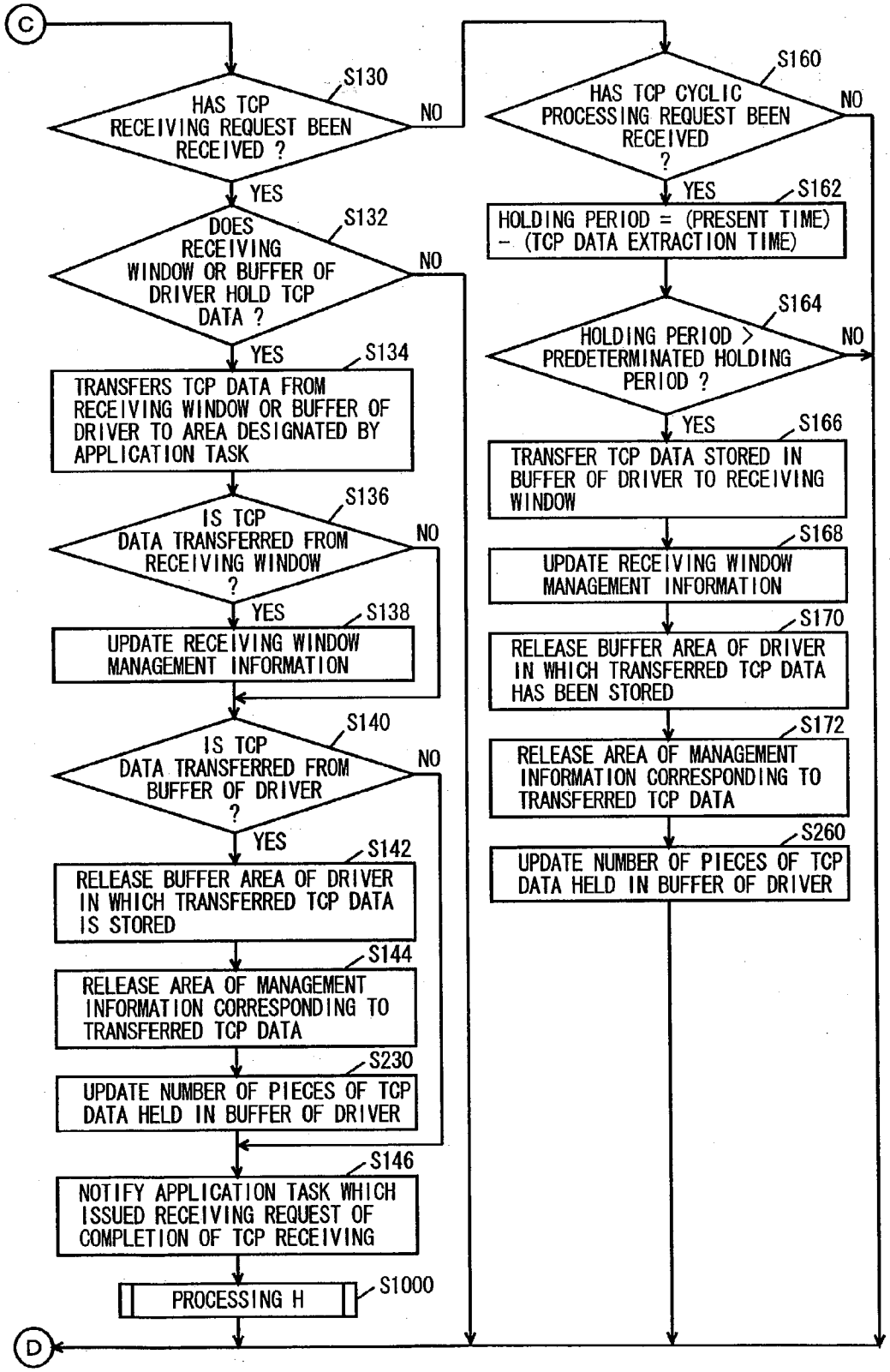

C
S130
HAS TCP RECEIVING REQUEST BEEN RECEIVED ?
NO
YES
S132
DOES RECEIVING WINDOW OR BUFFER OF DRIVER HOLD TCP DATA ?
NO
YES
S134
TRANSFERS TCP DATA FROM RECEIVING WINDOW OR BUFFER OF DRIVER TO AREA DESIGNATED BY APPLICATION TASK
S136
IS TCP DATA TRANSFERRED FROM RECEIVING WINDOW ?
NO
YES
S138
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S140
IS TCP DATA TRANSFERRED FROM BUFFER OF DRIVER ?
NO
YES
S142
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA IS STORED
S144
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA
S230
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S146
NOTIFY APPLICATION TASK WHICH ISSUED RECEIVING REQUEST OF COMPLETION OF TCP RECEIVING
S1000
PROCESSING H
D
S160
HAS TCP CYCLIC PROCESSING REQUEST BEEN RECEIVED ?
NO
YES
S162
HOLDING PERIOD = (PRESENT TIME) - (TCP DATA EXTRACTION TIME)
S164
HOLDING PERIOD > PREDETERMINATED HOLDING PERIOD ?
NO
YES
S166
TRANSFER TCP DATA STORED IN BUFFER OF DRIVER TO RECEIVING WINDOW
S168
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S170
RELEASE BUFFER AREA OF DRIVER IN WHICH TRANSFERRED TCP DATA HAS BEEN STORED
S172
RELEASE AREA OF MANAGEMENT INFORMATION CORRESPONDING TO TRANSFERRED TCP DATA
S260
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER

FIG. 32

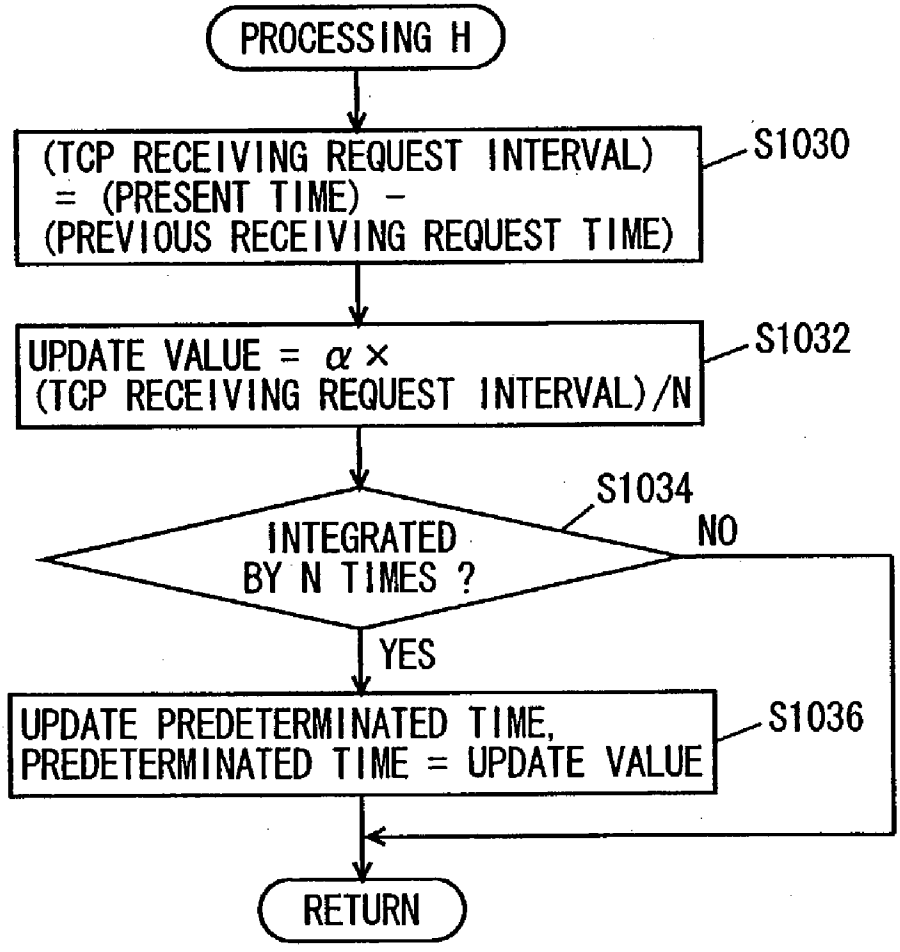

PROCESSING H
(TCP RECEIVING REQUEST INTERVAL) = (PRESENT TIME) - (PREVIOUS RECEIVING REQUEST TIME)
S1030
UPDATE VALUE = α × (TCP RECEIVING REQUEST INTERVAL)/N
S1032
INTEGRATED BY N TIMES ?
S1034
NO
YES
UPDATE PREDETERMINATED TIME, PREDETERMINATED TIME = UPDATE VALUE
S1036
RETURN

FIG. 33

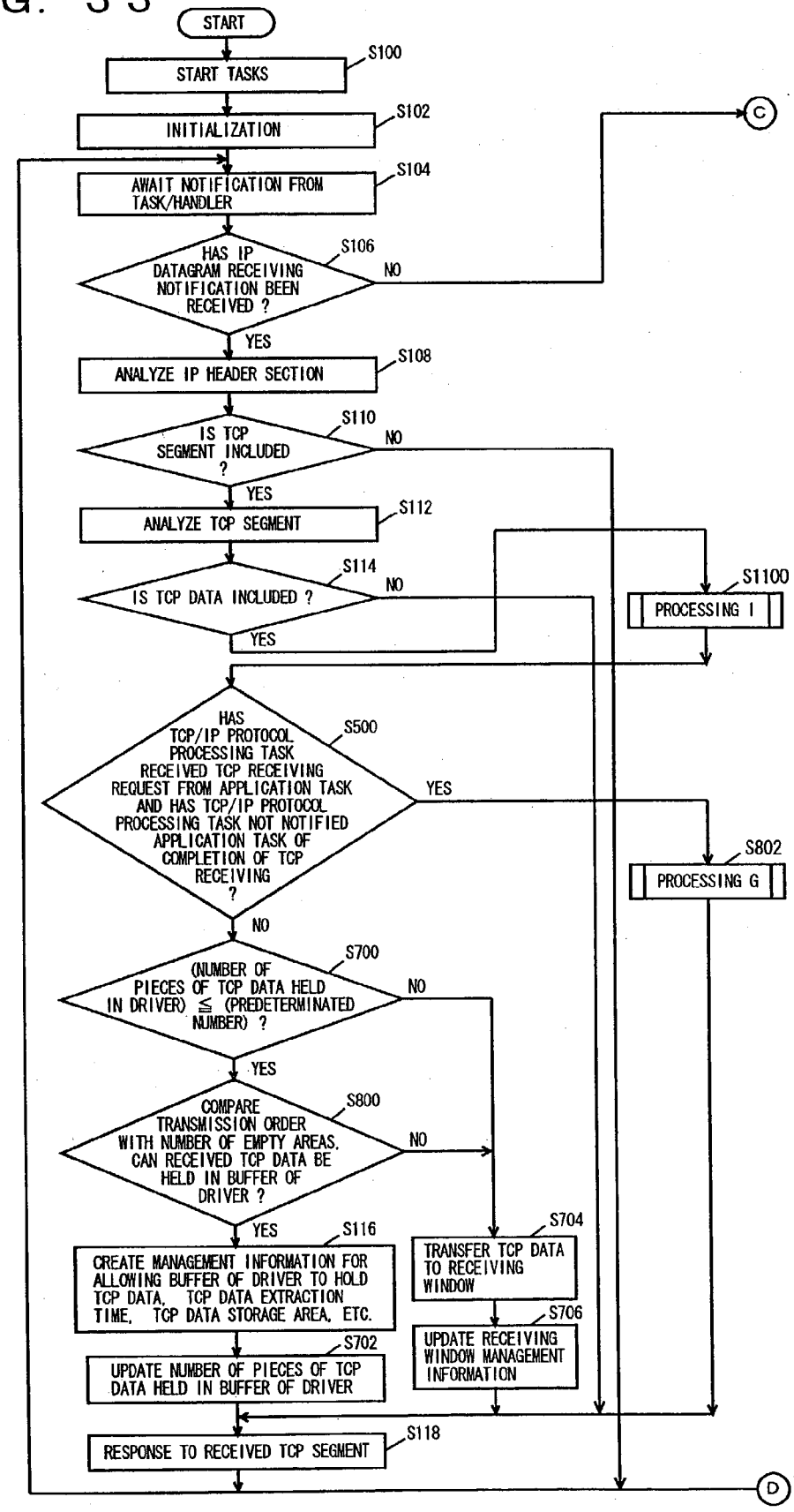
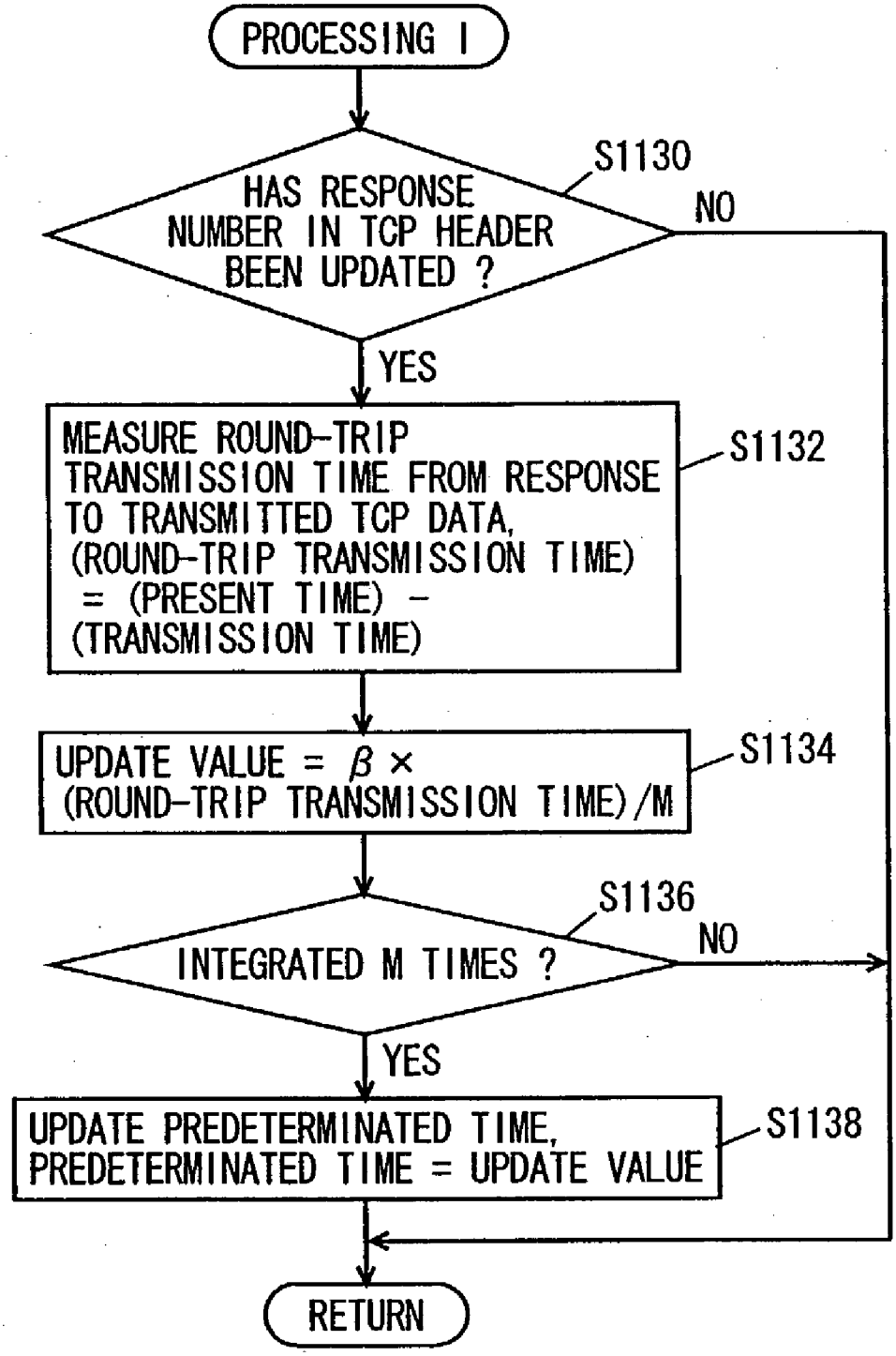

START
START TASKS
S100
INITIALIZATION
S102
AWAIT NOTIFICATION FROM TASK/HANDLER
S104
HAS IP DATAGRAM RECEIVING NOTIFICATION BEEN RECEIVED ?
S106
NO
YES
ANALYZE IP HEADER SECTION
S108
IS TCP SEGMENT INCLUDED ?
S110
NO
YES
ANALYZE TCP SEGMENT
S112
IS TCP DATA INCLUDED ?
S114
NO
YES
PROCESSING I
S1100
HAS TCP/IP PROTOCOL PROCESSING TASK RECEIVED TCP RECEIVING REQUEST FROM APPLICATION TASK AND HAS TCP/IP PROTOCOL PROCESSING TASK NOT NOTIFIED APPLICATION TASK OF COMPLETION OF TCP RECEIVING ?
S500
YES
PROCESSING G
S802
NO
(NUMBER OF PIECES OF TCP DATA HELD IN DRIVER) ≦ (PREDETERMINATED NUMBER) ?
S700
NO
YES
COMPARE TRANSMISSION ORDER WITH NUMBER OF EMPTY AREAS, CAN RECEIVED TCP DATA BE HELD IN BUFFER OF DRIVER ?
S800
NO
YES
CREATE MANAGEMENT INFORMATION FOR ALLOWING BUFFER OF DRIVER TO HOLD TCP DATA, TCP DATA EXTRACTION TIME, TCP DATA STORAGE AREA, ETC.
S116
TRANSFER TCP DATA TO RECEIVING WINDOW
S704
UPDATE RECEIVING WINDOW MANAGEMENT INFORMATION
S706
UPDATE NUMBER OF PIECES OF TCP DATA HELD IN BUFFER OF DRIVER
S702
RESPONSE TO RECEIVED TCP SEGMENT
S118
C
D

FIG. 34


PROCESSING I
S1130
HAS RESPONSE NUMBER IN TCP HEADER BEEN UPDATED ?
NO
YES
MEASURE ROUND-TRIP TRANSMISSION TIME FROM RESPONSE TO TRANSMITTED TCP DATA, (ROUND-TRIP TRANSMISSION TIME) = (PRESENT TIME) - (TRANSMISSION TIME)
S1132
UPDATE VALUE = β × (ROUND-TRIP TRANSMISSION TIME)/M
S1134
S1136
INTEGRATED M TIMES ?
NO
YES
UPDATE PREDETERMINATED TIME, PREDETERMINATED TIME = UPDATE VALUE
S1138
RETURN

COMMUNICATION DEVICE FOR PROCESSING DATA RECEIVED FROM NETWORK

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a network communication technique, and particularly to a technique for increasing a communication processing rate if data is received from a network using TCP/IP (Transmission Control Protocol/Internet Protocol).

[0003] 2. Description of the Background Art

[0004] TCP/IP protocol is widely used in data communication executed on the Internet. In recent years, many types of mobile terminals having an Internet browser function exist. The TCP/IP protocol is used for equipment installed to these mobile terminals. Generally, there is a limit to the processing capability and power consumption of a CPU (Central Processing Unit) of such an installed equipment. It is, therefore, necessary to reduce a processing quantity and power consumption required for the TCP/IP protocol.

[0005] Ordinary processings in a case where an Ethernet frame including TCP/IP packets is received on the network using the TCP/IP protocol will now be described. A communication equipment which receives the Ethernet frame is notified by a network controller that a network driver received the Ethernet frame. The network driver reads the received Ethernet frame from the network controller and transfers the read frame to the buffer of the network driver. A TCP/IP protocol processing section sequentially analyzes the Ethernet frame, an IP datagram included in the Ethernet frame and a TCP segment included in the IP datagram. The TCP/IP protocol processing section extracts a data part in the TCP segment and transfers the extracted data part to a receiving window. If receiving data according to the TCP protocol, this receiving window is a receiving buffer which is necessary to TCP specifications.

[0006] Under the regulations of the TCP protocol, if a TCP/IP data packet is transmitted to the other equipment on the network, it is necessary to include the empty size of the receiving window in a TCP header. Data is held in the receiving window until a data receiving request according to TCP protocol is issued from an application task. When a data receiving request according to the TCP protocol is issued from the application task, data is transferred from the receiving window to a buffer designated by the application task.

[0007] As can be seen, according to the ordinary TCP/IP protocol, the data received from the other equipment on the network is transferred from the buffer of the network driver through the receiving window to the buffer designated by the application task. Under the regulations of the TCP/IP protocol, a transmission end communication equipment transmits data in accordance with the empty size of the receiving window notified from the receiving end communication equipment. The receiving end communication equipment is prohibited to decrease the receiving window size halfway along the communication. For this reason, a memory area with a fixed length or a memory area the size of which is not decreased halfway along the communication is normally set in the receiving window so as to realize the TCP/IP protocol.

[0008] However, in the processing performed by the receiving end communication equipment, the received data is temporarily transferred to the receiving window and then transferred to the buffer designated by the application task. As a result, the number of times of data transfer increases. Due to this, load on the CPU and hardware necessary for the TCP/IP protocol processing increases to thereby disadvantageously increase power consumption, and it is difficult to secure an empty size in the receiving window of the receiving end communication equipment to thereby disadvantageously decrease data communication rate.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to provide a communication device and a mobile terminal capable of decreasing the number of times of data transfer between buffers if data is received from a network according to a protocol specified by TCP/IP or the like.

[0010] It is another object of the present invention to provide a communication device and a mobile terminal capable of transferring data with low power consumption if the data is received from a network.

[0011] It is yet another object of the present invention to provide a communication device and a mobile terminal capable of executing a data receiving processing at high rate if data is received from a network.

[0012] It is still another object of the present invention to provide a communication device and a mobile terminal capable of executing a data receiving processing to correspond to a buffer specification if data is received from a network.

[0013] A communication device according to the present invention includes: a network control circuit controlling transmission and reception of a data item for a network; a first storage circuit connected to the network control circuit, and temporarily storing the received data item; a second storage circuit connected to the first storage circuit, and storing the received data item; and a control circuit controlling the data item stored in the first storage circuit and the second storage circuit to be transferred to a predetermined buffer. The control circuit includes: a first transfer control circuit controlling the first storage circuit to transfer the data item stored in the first storage circuit to the buffer in response to a request to store data in the buffer, the request issued before preset time passes since the data item has been stored in the first storage circuit; and a second transfer control circuit controlling the second storage circuit to transfer the data item stored in the first storage circuit to the second storage circuit when the preset time passes since the data item has been stored in the first storage circuit, and to transfer the data item stored in the second storage circuit to the buffer in response to the request to store data in the buffer.

[0014] If network communication is held according to, for example, the TCP/IP protocol, the communication device has the buffer of a communication driver serving as the first storage circuit and a receiving window serving as the second storage circuit. If the network control circuit detects the reception of a data item, the data item is stored in the buffer of the communication driver. If a data receiving request is issued from an application task before preset time passes

since the data item has been stored in the buffer of the communication driver, the data item stored in the communication driver is transferred to a buffer designated by the application task. In this case, the received data item does not go through the receiving window. On the other hand, when the preset time passes since the data item has been stored in the buffer of the communication driver, the data item stored in the buffer of the communication driver is transferred to the receiving window. Thereafter, when the data receiving request is issued from the application task, the data item stored in the receiving window is transferred to the buffer designated by the application task. In this case, the received data item goes through the receiving window. By doing so, all the received data items are not transferred from the buffer of the communication driver to the receiving window but only the data items for which no receiving request is issued from the application task before the preset time passes are transferred from the buffer of the communication driver to the receiving window. As a result, it is possible to provide a communication device capable of decreasing the number of times of data transfer between the buffers and executing a data receiving processing at high rate with low power consumption if data is received. It is noted that the empty size of the receiving window serving as the second storage circuit is decreased in accordance with the size of the received data items stored in the receiving window. In addition, the empty size of the receiving window is increased in accordance with the size of data items read from the receiving window by the application task. The empty size of this receiving window is transmitted to the other device on the network. The communication device according to the first aspect stores the data to be stored in the receiving window which serves as the second storage circuit, in the buffer of the network driver which serves as the first storage circuit. The empty size of the receiving window transmitted to the other device on the network is calculated for not only the data stored in the receiving window but also the data stored in the network driver (i.e., calculated to include not only the empty size of the receiving window but also the empty size of the buffer of the network driver). In other words, the empty size of the receiving window transmitted to the other device on the network is a size obtained by subtracting the size of the data stored in the receiving window and the size of the data stored in the network driver from the size of the receiving window. In addition, the empty size of the receiving window transmitted to the other device on the network is not a size obtained by adding the empty size of the receiving window and the empty size of the buffer of the network driver. If so, the empty size of the receiving window transmitted to the other device on the network becomes equal to the empty size of the receiving window of a conventional device. Therefore, the communication device according to the present invention does not contradict the TCP/IP protocol specification.

[0015] It is more preferable that the first control circuit includes a circuit transferring the data item stored in the first storage circuit to the buffer in response to the request to store the data in the buffer, the request issued before the preset time passes since the data item has been stored in the first storage circuit, until a preset number of data items have been stored in the first storage circuit. The second control circuit includes a circuit transferring the data item stored in the first storage circuit to the second storage circuit if one of a condition that preset time passes since the data item has been stored in the first storage circuit and a condition that the preset number of data items have been stored in the first storage circuit is satisfied, and transferring the data item stored in the second storage circuit to the buffer in response to the request to store the data in the buffer.

[0016] If one of the two conditions, i.e., the condition that the preset time passes since the data item has been stored in the buffer of the communication driver and the condition that the preset number of data items have been stored in the buffer of the communication driver, is satisfied, the data item is transferred from the communication driver to the receiving window. As a result, the data item for which no receiving request is issued from the application task before the preset time passes is transferred from the communication driver to the receiving window. In this case, even before the preset time passes, if the preset number of data items are stored in the buffer of the communication driver, the data items exceeding the preset number are transferred from the buffer of the communication driver to the receiving window. As a result, the buffer of the communication driver always stores only data items not greater than the preset number, making it possible to secure a constant size of an empty area. Consequently, it is possible to decrease the probability that data cannot be transmitted to the buffer of the communication driver because of lack of the empty buffer of the communication driver.

[0017] It is further preferable that the first transfer control circuit includes a circuit transferring the data item stored in the first storage circuit to the buffer in response to a request to store data in the buffer, the storage request issued before preset time passes since the data item has been stored in the first storage circuit, until a preset capacity of data items have been stored in the first storage circuit. The second transfer control circuit includes a circuit transferring the data item stored in the first storage circuit to the second storage circuit if one of a condition that the preset time passes since the data item has been stored in the first storage circuit and a condition that the preset capacity of data items have been stored in the first storage circuit is satisfied, and transferring the data item stored in the second storage circuit to the buffer in response to the request to store the data in the buffer.

[0018] If one of the two conditions, i.e., the condition that the preset time passes since the data item has been stored in the buffer of the communication driver and the condition that the preset capacity of data items have been stored in the buffer of the communication driver, is satisfied, the data item is transferred from the communication driver to the receiving window. As a result, the data item for which no receiving request is issued from the application task before the preset time passes is transferred from the buffer of the communication driver to the receiving window. In this case, even before the preset time passes, if the preset capacity of data items are stored in the buffer of the communication driver, the data items exceeding the preset capacity are transferred from the buffer of the communication driver to the receiving window. As a result, the buffer of the communication driver always stores only data items not greater than the preset capacity, thereby making it possible to secure a constant size of an empty area. Consequently, it is possible to decrease the instance that data cannot be transmitted to the buffer of the communication driver because of lack of the empty buffer of the communication driver.

[0019] It is also preferable that the preset time is set based on a communication state of the network.

[0020] The preset time can be set based on the communication state of the network. For example, the communication device measures transmission time required for transmitting a data item from the transmission end to the receiving end. If this transmission time is relatively long, time required for the data item to reach the receiving end from the transmission end becomes long, as well. Therefore, the preset time may be set long. By doing so, it is possible to decrease the number of times of temporarily transferring the data item stored in the buffer of the driver to the receiving window and then transferring the data item to the buffer of the application task.

[0021] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] **FIG. 1** is a control block diagram of a PDA into which a communication device according to embodiments of the present invention is installed;

[0023] **FIG. 2** is a block diagram of a program configuration executed by a CPU shown in **FIG. 1**;

[0024] **FIG. 3** is a view showing a structure of data received and transmitted by a communication device according to the embodiments of the present invention;

[0025] **FIGS. 4 and 5** are flowcharts showing processing procedures executed by a communication device according to a first embodiment of the present invention;

[0026] FIGS. **6** to **8** are explanatory views for a transfer processing executed by the communication device according to the first embodiment of the present invention;

[0027] **FIGS. 9 and 10** are flowcharts showing processing procedures executed by a communication device according to a second embodiment of the present invention;

[0028] FIGS. **11** to **13** are explanatory views for a transfer processing executed by the communication device according to the second embodiment of the present invention;

[0029] **FIG. 14** is a flowchart showing processing procedures executed by a communication device according to a third embodiment of the present invention;

[0030] FIGS. **15** to **17** are explanatory views for a transfer processing executed by the communication device according to the third embodiment of the present invention;

[0031] **FIG. 18** is a flowchart showing processing procedures executed by a communication device according to a fifth embodiment of the present invention;

[0032] **FIGS. 19 and 20** are explanatory views for a transfer processing executed by the communication device according to the fifth embodiment of the present invention;

[0033] **FIGS. 21 and 22** are flowcharts showing processing procedures executed by a communication device according to a sixth embodiment of the present invention;

[0034] FIGS. **23** to **26** are explanatory views for a transfer processing executed by the communication device according to the sixth embodiment of the present invention;

[0035] **FIGS. 27 and 28** are flowcharts showing processing procedures executed by a communication device according to a seventh embodiment of the present invention;

[0036] **FIGS. 29 and 30** are flowcharts showing processing procedures executed by a communication device according to an eighth embodiment of the present invention;

[0037] **FIGS. 31 and 32** are flowcharts showing processing procedures executed by a communication device according to a tenth embodiment of the present invention; and

[0038] **FIGS. 33 and 34** are flowcharts showing processing procedures executed by a communication device according to an eleventh embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Hereinafter, the embodiments of the present invention will be described with reference to the drawings. It is noted that the same components are denoted by the same reference symbols, respectively, in the following description and the drawings. The names and functions thereof are the same. These components will not be, therefore, repeatedly described.

[0040] First Embodiment

[0041] A control block of a PDA (Personal Digital Assistant) into which a communication device according to the first embodiment of the present invention is installed will be described with reference to **FIG. 1**. As shown in **FIG. 1, a** PDA **100** includes an Ethernet controller **110** which is an interface with the network and which notifies a CPU **120** of an interrupt signal when data transmission and reception is completed, CPU **120** which controls the entirety of PDA **100**, and an LCD (Liquid Crystal Display) **130** and a touch panel **140** which are man-machine interfaces, a ROM (Read Only Memory) **150** and a RAM (Random Access Memory) **160** which store a program for executing a processing to the described later and operation results halfway along the execution of the program. In addition, Ethernet controller **110** is connected to a connector **190** for the connection to the network.

[0042] Referring to **FIG. 2, a** configuration of a program receiving processing executed by the communication device according to this embodiment will be described. When detecting that a frame addressed to its own station is transmitted over an Ethernet cable, Ethernet controller **110** performs receiving processings including an error detect processing to the frame. Thereafter, Ethernet controller **110** notifies an Ethernet driver processing section **122** of the receiving of the Ethernet frame by performing an interrupt processing.

[0043] Ethernet driver processing section **122** is started in response to the interrupt signal from Ethernet controller **110** and analyzes the header part of the received Ethernet frame. If an IP datagram is included in the Ethernet frame, Ethernet driver processing section **122** notifies a TCP/IP protocol processing task **124** of the receiving of the IP datagram.

[0044] If data according to the TCP/IP protocol is received, an application task **126** notifies a data receiving

request to TCP/IP protocol task **124**. At this moment, application task **126** also notifies TCP/IP protocol task **124** of information about an address at which the TCP/IP protocol data is stored, the size of the TCP/IP protocol data or the like. Application task **126** is set in a wait state until TCP/IP protocol processing task **124** notifies application task **126** of the completion of receiving.

[**0045**] A cyclic handler **128** is started at preset time intervals and instructs TCP/IP protocol processing task **124** to cyclically execute a communication processing.

[**0046**] TCP/IP protocol processing task **124** executes a TCP/IP protocol processing in response to the notification from application task **126**, cyclic handler **128**, Ethernet driver processing section **122** or the like.

[**0047**] Referring to **FIG. 3**, the structure of data processed by the communication device according to the first embodiment will be described. As shown in **FIG. 3**, the Ethernet frame includes a header and data. The data of the Ethernet frame is referred to as "IP datagram" which includes a header and data. The data of the IP datagram is referred to as "TCP segment" which includes a header and data.

[**0048**] The header of the TCP segment stores order numbers indicating a data transmission order, data size and the like. The data of the TCP segment stores data (e.g., D(0), D(1), D(2) and D(3)) to be used by an application task.

[**0049**] Referring to **FIG. 4**, the program executed by PDA **100** into which the communication device according to this embodiment is installed has the following control structure.

[**0050**] In step (abbreviated to as "S" hereinafter) **100**, CPU **120** starts various tasks. In **S102**, CPU **120** performs an initialization processing. At this moment, variables and the like are initialized.

[**0051**] In **S104**, CPU **120** awaits a notification from a task or a handler. In **S106**, CPU **120** determines whether or not CPU **120** has received an IP datagram receiving notification. If the IP datagram receiving notification is received ("YES" in **S106**), processing proceeds to **S108**. If not ("NO" in **S106**), the processing proceeds to **S130** shown in **FIG. 5**.

[**0052**] In **S108**, CPU **120** analyzes an IP header part. In **S110**, CPU **120** determines whether or not a TCP segment is included. If a TCP segment is included ("YES" in **S110**), the processing proceeds to **S112**. If not ("NO" in **S110**), the processing returns to **S104**.

[**0053**] In **S112**, CPU **120** analyzes the TCP segment. In **S114**, CPU **120** determines whether or not TCP data is included. If TCP data is included ("YES" in **S114**), the processing proceeds to **S116**. If not ("NO" in **S114**), the processing proceeds to **S118**.

[**0054**] In **S116**, CPU **120** creates management information for allowing the driver of Ethernet driver processing section **122** to hold the TCP data. The created information includes time at which the TCP data is extracted, a TCP data storage area and the like.

[**0055**] In **S118**, CPU **120** performs a response processing in response to the received TCP segment. The processing then returns to **S104**.

[**0056**] Referring to **FIG. 5**, in **S130**, CPU **120** determines whether or not a TCP receiving request has been received. If the TCP receiving request has been received ("YES" in **S130**), the processing proceeds to **S132**. If not ("NO" in **S130**), the processing proceeds to **S160**.

[**0057**] In **S132**, CPU **120** determines whether or not a receiving window or the buffer of the driver holds the TCP data. If the receiving window or the buffer of the driver has TCP data ("YES" in **S132**), the processing proceeds to **S134**. If not ("NO" in **S132**), the processing returns to **S104** in **FIG. 4**.

[**0058**] In **S134**, CPU **120** transfers the TCP data from the receiving window or the buffer of the driver to a buffer area designated by the application task.

[**0059**] In **S136**, CPU **120** determines whether or not the TCP data is transferred from the receiving window. If the TCP data is transferred from the receiving window ("YES" in **S136**), the processing proceeds to **S138**. If not ("NO" in **S136**), the processing proceeds to **S140**.

[**0060**] In **S138**, CPU **120** updates receiving window management information. In **S140**, CPU **120** determines whether or not the TCP data is transferred from the buffer of the driver. If the TCP data is transferred from the buffer of the driver ("YES" in **S140**), the processing proceeds to **S142**. If not ("NO" in **S140**), the processing proceeds to **S146**.

[**0061**] In **S142**, CPU **120** releases the buffer area of the driver in which the transferred TCP data is stored. In **S144**,CPU **120** releases the area of the management information corresponding to the transferred TCP data.

[**0062**] In **S146**, CPU **120** notifies the application task which issued the receiving request of the completion of TCP receiving. Thereafter, the processing returns to **S104** shown in **FIG. 4**.

[**0063**] In **S160**, CPU **120** determines whether or not a TCP cyclic processing request has been received. If the TCP cyclic processing request has been received ("YES" in **S160**), the processing proceeds to **S162**. If not ("NO" in **S160**), the processing proceeds to **S104** shown in **FIG. 4**.

[**0064**] In **S162**, CPU **120** sets holding time as holding time=(present time)−(TCP data extraction time). In **S164**, CPU **120** determines whether or not the holding time is longer than preset holding time. If the holding time is longer than the preset holding time ("YES" in **S164**), the processing proceeds to **S166**. If not ("NO" in **S164**), the processing proceeds to **S104** shown in **FIG. 4**.

[**0065**] In **S166**, CPU **120** transfers the TCP data stored in the buffer of the driver to the receiving window. In **S168**, CPU **120** updates the receiving window management information. In **S170**, CPU **120** releases the buffer area of the driver in which the transferred TCP data is stored. In **S172**, CPU **120** releases the area of the management information corresponding to the transferred TCP data. Thereafter, the processing returns to **S104** shown in **FIG. 4**.

[**0066**] The operation of PDA **100** including the communication device according to this embodiment based on the above-mentioned structure and flowcharts will be described.

[**0067**] FIGS. **6** to **8** show processing procedures if PDA **100** including the communication device according to this embodiment receives an Ethernet frame including a TCP/IP packet from the Ethernet.

[0068] As shown in **FIG. 6**, Ethernet controller **110** detects a frame having an Ethernet address addressed to its own station from Ethernet frames flowing on the Ethernet ("YES" in S**106**). Ethernet controller **110** stores the received frame in the memory. Ethernet controller **110** notifies Ethernet driver **122** of the receiving of the frame. Ethernet driver **122** transfers the Ethernet frame received from Ethernet controller **110** to the buffer of the driver. TCP/IP protocol processing task **124** analyzes the Ethernet frame stored in the buffer of the driver, the IP datagram included in the Ethernet frame and header information and data on the TCP segment included in the IP datagram (in S**108** and S**112**), determines whether or not the frame and the like are addressed to its own station, whether or not there is an error in the data and the like, and finally extracts TCP data D(0) ("YES" in S**114**).

[0069] Data D(0) is not transferred to the receiving window. Instead, data D(0) is held in the buffer of the driver. At this moment, information for managing time T(0) at which data D(0) was extracted, memory arrangement address information on data D(0), the size of data D(0) and the like is created (in S**116**). Likewise, if three other Ethernet frames are received, data D(1) to D(3) is held in the buffer of the driver and management information including time T(1) to T(3) for which data D(1) to D(3) is held and the like is created. It is assumed herein that time for holding each of data D(0) to D(3) in the buffer of the driver is not longer than preset time.

[0070] **FIG. 7** shows a case where the TCP data receiving request is issued from application task **126** by preset time. If the receiving request is issued from application task **126**, the management information corresponding to data D(0) to D(3) held in the buffer of the driver is referred to and data D(0) to D(3) is transferred from the buffer of the driver to a buffer designated by application task **126** (in S**134**). The management information corresponding to transferred data D(0) to D(3) is erased (in S**144**).

[0071] Here, if the total size of data D(0) to D(3) held in the buffer of the driver is larger than the size of the buffer designated by application task **126**, some of data D(0) to D(3) held in the buffer of the driver is transferred by as much as a size equal to that of the buffer designated by application task **126**. Only the management information on the data completely transferred is erased and data which is not completely transferred is held in the buffer of the driver (including a case where only a part of the data is transferred) and the management information is updated so as to correspond to the data.

[0072] **FIG. 8** shows a case were no TCP data receiving request is issued from application task **126** by the preset time. If a receiving request is not issued from application task **126** at certain time T, the management information corresponding to data D(0) to D(3) stored in the buffer of the driver is referred to and periods dT(0) to dT(3) from time T until time T(0) to T(3) for which the respective data is held are calculated (in S**162**).

[0073] If periods dT(O) to dT(3) exceed preset time; data D(0) to D(3) is transferred from the buffer of the driver to the receiving window (in S**166**) and the management information corresponding to the transferred data is erased (in S**172**).

[0074] As can be seen, in a PDA into which the communication device according to this embodiment is installed, if the receiving request is issued from the application task by the preset time, data is transferred from the buffer of the driver to the buffer designated by the application task without going through the receiving window. Due to this, compared with the conventional art, the number of times of data transfer is decreased. By decreasing the number of times of data transfer, power consumption required for the TCP protocol processing is decreased. In addition, if the receiving request is not issued from the application task with the preset time exceeded, the data held in the driver is transferred to the receiving window. Due to this, compared with a case where no time limitation is given, the probability that the buffer of the driver is occupied by data decreases. As a result, if an Ethernet frame which does not include a packet according to the TCP/IP protocol (such as a packet according to ARP (Address Resolution Protocol), ICMP (Internet Control Message Protocol), UDP/IP (User Datagram Protocol/Internet Protocol or the like), it is possible to decrease the probability that the Ethernet controller cannot transfer the received Ethernet frame even while a plurality of applications are executed and communication with a plurality of equipment are held. Consequently, it is possible to prevent transfer rate at the time of receiving data from being decreased.

[0075] In this embodiment, a case where the data according to the TCP protocol included in the Ethernet frame is received has been described. However, the present invention is not limited to this case. For example, even if TCP data included in the other frame, e.g., a PPP (Point-to-Point Protocol) frame is received, the communication device according to this embodiment can be used. A transmission path is not limited to the Ethernet but may be the other transmission path such as a transmission path utilizing a telephone line using a modem.

[0076] Second Embodiment

[0077] A PDA which includes a communication device according to the second embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0078] Referring to FIGS. **9** to **10**, a program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 9**, the same processings as those in the flowchart shown in **FIG. 4** are denoted by the same step numbers, respectively. In the flowchart shown in **FIG. 10**, the same processings as those in the flowchart shown in **FIG. 5** are denoted by the same step numbers, respectively. These processings will not be, therefore, repeatedly described herein.

[0079] In S**200**, CPU **120** determines whether or not the number of pieces of TCP data held in the driver is not greater than a preset number. If the number of pieces of TCP data held in the driver is not greater than a preset number ("YES" in S**200**), the processing proceeds to S**116**. If not ("NO" in S**200**), the processing proceeds to S**204**.

[0080] In S**202**, CPU **120** updates the number of pieces of TCP data held in the buffer of the driver.

[0081] In S**204**, CPU **120** transfers the TCP data to the receiving window. In S**206**, CPU **120** updates management information on the receiving window.

[0082] After S202 and S206, the processing proceeds to S118.

[0083] Referring to FIG. 10, if a TCP receiving request is received, CPU 120 updates the number of pieces of TCP data held in the buffer of the driver in S230.

[0084] If the TCP cyclic processing request is received, CPU 120 updates the number of pieces of TCP data held in the buffer of the driver in S260.

[0085] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described.

[0086] FIGS. 11 to 13 show processing procedures if the PDA according to this embodiment receives an Ethernet frame including TCP/IP packets. In this embodiment, as in the case of the first embodiment, after TCP segment data is extracted, the data is not transferred to the receiving window but held in the buffer of the driver until preset time. The second embodiment, however, differs from the first embodiment in that the number of pieces of data held in the buffer of the driver is limited to not greater than a preset number. Namely, if data exceeding the preset number is received, the received data is not held in the buffer of the driver but transferred to and held in the receiving window.

[0087] FIG. 11 shows a case were the preset number of pieces of data is "2". Data D(0) to D(1) received by the PDA is held in the buffer of the driver until a receiving request is issued from application task 126 before the respective preset data passes as in the case of the first embodiment ("YES" in S200). Data D(2) to D(3) received thereafter is transferred from the buffer of the driver to the receiving window and held in the receiving window. This is because the number of pieces of data exceeds the preset number ("NO" in S200).

[0088] FIG. 12 shows a case where a receiving request is issued from application task 126 after the processing shown in FIG. 11 and if periods for which data D(0) to D(1) is held in the buffer of the driver fall within preset periods, respectively. When a receiving request is issued from application task 126 ("YES" in S130), management information corresponding to data D(0) to D(1) held in the buffer of the driver is referred to and data D(0) to D(1) is transferred from the buffer of the driver to a buffer designated by application task 126 (in S134). The management information corresponding to data D(0) to D(1) transferred from the buffer of the driver is erased (in S144).

[0089] It is determined whether or not there is data held in the receiving window (in S132), and data D(2) to D(3) is transferred from the receiving window to the buffer designated by application task 126 (in S134). Here, if the total size of data D(0) to D(3) is larger than the size of the buffer designated by application task 126, some of data D(0) to D(3) is transferred by as much as a size equal to the size of the buffer designated by application task 126 and remaining data is continuously held.

[0090] FIG. 13 shows a case where a TCP protocol data receiving request is not issued from application task 126 after the processing shown in FIG. 11 and even if the periods for which data D(0) to D(1) is held in the buffer of the driver exceed a preset period. If no receiving request is issued from application task 126 at certain time T, management information corresponding to data D(0) to D(1) stored in the buffer of the driver is referred to and periods dT(0) to dT(1) from time T until time T(0) to T(1) for which the respective data is held are calculated (in S162). If periods dT(0) to dT(1) exceed the preset time ("YES" in S164), data D(0) to D(1) is transferred from the buffer of the driver to the receiving window (in S166) and the management information corresponding to the respective data is erased (in S172).

[0091] As can be seen, in the PDA including the communication device according to this embodiment, if a receiving request is issued from the application task before preset time, data D(0) to D(1) is transferred from the buffer of the driver to the buffer designated by the application task without going through the receiving window. In addition, since the number of pieces of data held in the buffer of the driver is limited to not greater than the preset number, it is possible to secure the empty capacity of the buffer of the driver by as much as the predetermined number of data. Due to this, even if an Ethernet frame which does not include TCP/IP packets is received or even if a plurality of application tasks are executed on the PDA and the respective application tasks communicate with other devices, it is possible to decrease the probability that the Ethernet frame received by the Ethernet controller cannot be transferred to the buffer of the driver.

[0092] Third Embodiment

[0093] A PDA which includes a communication device according to the third embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0094] Referring to FIG. 14, a program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in FIG. 14, the same processings as those in the flowchart shown in FIG. 9 are denoted by the same step numbers, respectively. These processings will not be, therefore, repeatedly described herein.

[0095] In S300, CPU 120 compares a transmission order with the number of empty areas and determines whether or not the received TCP data can be held in the buffer of the driver. If the comparison between the transmission order and the number of empty areas shows that the TCP data can be held in the buffer of the driver ("YES" in S300), the processing proceeds to 5116. If not ("NO" in S300), the processing proceeds to S204.

[0096] After the processing in S116, the processing proceeds to S202 and S118 and then returns to S104.

[0097] After the processing in S204, the processing proceeds to S206 and S118 and then returns to S104.

[0098] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described.

[0099] FIGS. 15 to 17 show processings if the PDA including the communication device according to this embodiment receives an Ethernet frame which includes TCP/IP packets from the Ethernet. It is assumed herein that a transmission end communication device transmits the

Ethernet frame including data D(0), D(1), D(2), and D(3) in this order and that a receiving end the PDA receives the Ethernet frame including data D(0), D(2), D(1), and D(3) in this order.

[0100] In this embodiment, as in the case of the second embodiment, after the data of a TCP segment is extracted, the extracted data is not transferred to the receiving window but held in the buffer of the driver until preset time. Further, it is assumed that the number of pieces of data held in the buffer of the driver is not greater than a preset number. In the second embodiment, the data is held in the buffer of the driver by as much as the preset number of data in the order of receiving by the PDA. In this embodiment, by contrast, only the data in the order of transmission by the transmission end device and within a range of the preset number is held in the buffer of the driver. The other data is transferred from the buffer of the driver to the receiving window.

[0101] FIGS. **15** to **16** show a case where the preset number of pieces of data is "2". The transmission communication device transits the Ethernet including data D(0), D(1), D(2) and D(3) in this order. When receiving data D(0) and D(1) ("YES" in S**300**), the PDA performs processing in accordance with the order of transmission. The PDA holds the data in the buffer of the driver by preset time in accordance with the order of transmission. If other data D(2) and D(3) is received ("NO" in S**300**), the other data is transferred from the buffer of the driver to the receiving window (in S**204**).

[0102] Since there is a limitation that a period for which data is held in the buffer of the driver is within the preset time. Due to this, data D(0) is held in the buffer of the driver for the preset time. However, if no receiving request is issued from application task **126** by the preset time, processing procedures are those shown in **FIG. 17**. That is, data D(0) is transferred to the receiving window. After the transfer of data D(0), the number of pieces of data held in the buffer of the driver becomes "1". Due to this, if data D(3) is received, data D(3) is held in the buffer of the driver.

[0103] As can be seen, in the PDA including the communication device according to this embodiment, data processing is performed not in the order of receiving but in the order of transmission. Normally, the application task issues a TCP data receiving request in the order of transmission of data from the transmission end communication device. Even in that case, a receiving request is issued for the data transmitted later among the data transmitted from the transmission end communication device, from the application task at the same time as or after the time of the data transmitted previously. Due to this, it is possible to decrease the number of pieces of data transferred to the receiving window after the passage of preset time by limiting the number of pieces of data held in the buffer of the driver to not greater than a preset number based on the order of transmission, compared with a case where data is held based on the order of receiving.

[0104] Fourth Embodiment

[0105] A PDA which includes a communication device according to the fourth embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0106] In the second and third embodiments, it is determined whether or not the received data is to be held in the buffer of the driver based on the preset number. In the fourth embodiment, by contrast, the processings of the PDA are performed based on a different rule.

[0107] In this embodiment, based on not the preset number but on a preset data size, data is held in the buffer of the driver. That is, if the sum of the total size of data held in the buffer of the driver and the total size of received data is not larger than the preset data size, then the received data is held in the buffer of the driver. If the sum of the total size of data held in the buffer of the driver and the size of received data exceeds the preset data size, then all or part of the received data is transferred to the receiving window.

[0108] As can be seen, the PDA including the communication device according to this embodiment performs processings based on the data size instead of the number of pieces of data unlike the second and third embodiments. The other processings are the same as those in the second and third embodiment and will not be, therefore, repeatedly described herein.

[0109] As mentioned above, in the PDA including the communication device according to this embodiment, it is determined whether or not data is to be held in the buffer of the driver based on not the number of pieces of received data. Instead, it is determined whether or not data is to be held in the buffer of the driver by comparing the sum of the total size of the data held in the buffer of the driver and the total size of the received data with the preset data size. By doing so, if the size of the received data is relatively small, the number of the empty areas of the buffer of the driver increases compared with a case where the sizes of the respective received data are relatively large. In other word, it is possible to effectively utilize the buffer of the driver by as much as the increase of the empty areas of the buffer of the driver.

[0110] Fifth Embodiment

[0111] A PDA which includes a communication device according to the fifth embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0112] Referring to **FIG. 18, a** program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 18**, the same processings as those in the flowchart shown in **FIG. 4** are denoted by the same step numbers, respectively. These processings will not be, therefore, repeatedly described herein.

[0113] In S**500**, CPU **120** determines whether or not TCP/IP protocol processing task **124** has received a TCP receiving request from application task **126** and has not notified application task **126** of the completion of TCP receiving. That is, CPU **120** determines whether or not a TCP receiving request from application task **126** are waited. If TCP/IP protocol processing task **124** has received a TCP receiving request from application task and has not notified application task **126** of the completion of TCP receiving ("YES" in S**500**), then the processing proceeds to S**502**. If not ("NO" in S**500**), the processing proceeds to S**116**.

[0114] In S502, CPU 120 transfer the TCP data from the buffer of the driver to the buffer area designated by the application task. In S504, CPU 120 releases the area of the buffer of the driver in which the TCP data has been stored. Thereafter, the processing proceeds to S118 and then returns to S104.

[0115] After the processing in S116, the processing proceeds to S118 and then returns to S104.

[0116] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described.

[0117] FIGS. 19 to 20 show a case where an Ethernet frame including TCP/IP packets is received if a receiving request from application task 126 of the PDA including the communication device according to this embodiment is in a wait state.

[0118] As shown in FIG. 19, when a receiving request is issued from application task 126, no data is held in the receiving window and the buffer of the driver. This indicates that a receiving request issued from application task 126 is in a wait state.

[0119] FIG. 20 shows processing if a receiving request from application task 126 is in a wait state (see FIG. 19) and an Ethernet frame including TCP/IP packets is received. As shown in FIG. 20, Ethernet controller 110 detects a frame having an Ethernet address addressed to its own station from Ethernet frames flowing on the Ethernet. Ethernet controller 110 stores the received frame in the memory. Ethernet controller 110 notifies Ethernet driver 122 of the receiving of the frame.

[0120] Ethernet driver 122 transfers the frame received from Ethernet controller 110 to the buffer of the driver. TCP/IP protocol processing task 124 analyzes the Ethernet frame stored in the buffer of the driver, the IP datagram included in the Ethernet frame and header information and data on the TCP segment included in the IP datagram, determines whether or not the frame and the like are addressed to its own station, whether or not there is an error in the data and the like, and finally extracts data D(0) of the TCP segment. Thereafter, extracted data D(0) is transferred from the buffer of the driver directly to the buffer designated by application task 126 without going through the receiving window.

[0121] As can be seen, in PDA according to this embodiment, even if a receiving request from the application task-is issued before data is received, the data received after the receiving request is transferred from the buffer of the driver to the buffer designated by the application task without going through the receiving window. As a result, compared with the conventional art, it is possible to decrease the number of times of data transfer. Consequently, it is possible to decrease power consumption required for the TCP protocol processing.

[0122] Sixth Embodiment

[0123] A PDA which includes a communication device according to the sixth embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0124] Referring to FIG. 21, a program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in FIG. 21, the same processings as those in the flowchart shown in FIG. 18 are denoted by the same step numbers, respectively. These processings will not be, therefore, repeatedly described herein.

[0125] If TCP/IP protocol processing task 124 has received a TCP receiving request from application task 126 and has not notified application task 126 of the completion of TCP receiving, then CPU 120 performs a processing E in S600.

[0126] Referring to FIG. 22, processing E in S600 will be described. In S630, CPU 120 determines whether or not the size of the received TCP data is larger than the size of the buffer area designated by the application task. If the size of the received TCP data is larger than the size of the buffer area designated by the application task ("YES" in S630), the processing proceeds to S632. If not ("NO" in S630), the processing proceeds to S638.

[0127] In S632, CPU 120 transfers the data from the buffer of the driver to the buffer area designated by the application task by as much as the size of the buffer area designated by the application task. In S634, CPU 120 releases the buffer area of the driver in which the transferred TCP data has been stored. In S636, CPU 120 creates management information for allowing the buffer of the driver to hold the TCP data which has not been transferred. This management information includes TCP data extraction time, a TCP data storage area and the like. After the processing in S636, the processing proceeds to S118.

[0128] In S638, CPU 120 transfers the TCP data from the buffer of the driver to the buffer area designated by the application task. In S640, CPU 120 releases the buffer area of the driver in which the TCP data has been stored. Thereafter, the processing proceeds to S118.

[0129] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described.

[0130] FIGS. 23 to 26 show procedures for the transfer between the buffers in the PDA including the communication device according to this embodiment. In this embodiment, when a receiving request is issued from application task 126 of the PDA, no data is held in the receiving window and the buffer of the driver. FIGS. 23 to 26 show processings if a receiving request from application task 126 is set in a wait state until data is received and an Ethernet frame including TCP/IP packets is received from the Ethernet. It is assumed herein that the transmission end communication device transmits the Ethernet frame including data D(0), D(1), D(2) and D(3) in this order and that the receiving end PDA receives the Ethernet frame including data D(2), D(3), D(1) and D(0) in this order.

[0131] In this embodiment, as in the case of the fifth embodiment, the extracted TCP segment data is transferred not to the receiving window but to the buffer designated by the application task from the buffer of the driver. It is noted,

however, that only the data which can be contained in the buffer designated by the application task is transferred and the other data exceeding the preset number is held in the buffer of the driver. It is assumed herein that time for which the data is held in the buffer of the driver is not longer than preset time. Further, the data is held in the buffer of the driver, management information for managing data extraction time, memory arrangement address information on the data, the size of the data and the like is created (in **S116**).

[**0132**] The data held in the buffer of the driver is transferred to the buffer designated by application task **126** if a receiving request is issued from application task **126** by the preset time. If a receiving request is not issued from application task **126** by the preset time, the data is transferred from the buffer of the driver to the receiving window.

[**0133**] As shown in **FIG. 23**, if an Ethernet frame including data D(2) is received, data D(2) is extracted as in the case of the fifth embodiment. Thereafter, since data D(2) can be contained in the buffer designated by application task **126** ("NO" in **S630**), data D(2) is transferred to the buffer designated by application task **126**. If an Ethernet frame including data D(3) is received, data D(3) is extracted. However, data D(3) cannot be contained in the buffer designated by application task **126** ("YES" in **S630**). Due to this, data D(3) is held in the buffer of the driver. At this moment, information for managing time T(3) at which data D(3) was extracted, memory arrangement address information on data D(3), the size of data D(3) and the like is created (in **S636**). At this moment, since data transmitted before data D(2) is missing, a receiving request issued from application task **126** is continuously set in a wait state.

[**0134**] **FIG. 24** shows a case where Ethernet frames including data D(1) and D(0) are received thereafter. Since extracted data D(0) and D(1) can be contained in the buffer designated by application task **126** ("NO" in **S630**), data D(0) and D(1) is transferred to the buffer designated by application task **126** (in **S632**). By this time, continuous data D(0) to D(2) can be received, so that the wait state of the receiving request issued from application task **126** is released.

[**0135**] **FIG. 25** shows a case where time for which data D(3) is held in the buffer of the driver is not longer than preset time and a receiving request is reissued from application task **126**. When a receiving request is issued from application task **126**, the management information corresponding to data D(3) held in the buffer of the driver is referred to and data D(3) is transferred from the buffer of the driver to the buffer designated by application task **126**. The management information corresponding to transferred data D(3) is erased.

[**0136**] **FIG. 25** shows a case where the size of data D(3) held in the buffer of the driver is not larger than the size of the buffer designated by application task **126**. If the size of data D(3) held in the buffer of the driver exceeds the size of the buffer designated by application task **126**, data D(3) held in the buffer of the driver is transferred by as much as a size equal to the size of the buffer designated by application task **126**. The remaining data which has not been transferred, is continuously held in the buffer of the driver and management information is updated to correspond to data D(3).

[**0137**] **FIG. 26** shows a case where a receiving request is not reissued from application task **126** by the time for which data D(3) is held in the buffer of the driver exceeds the preset time. If no receiving request is issued from application task **126** at certain time T, the management information corresponding to data D(3) stored in the buffer of the driver is referred to and a period dT(3) from time T until time T(3) for which data D(3) is held is calculated. If period dT(3) exceeds a preset period, data D(3) is transferred from the buffer of the driver to the receiving window. At this moment, the management information corresponding to data D(3) is erased.

[**0138**] As can be seen, in the PDA including the communication device according to this embodiment, data D(0) to D(2) is transferred from the buffer of the driver to the buffer designated by the application task without going through the receiving window. By doing so, it is possible to decrease the number of times of data transfer, compared with the conventional art. In addition, if a receiving request is issued from the application task by the preset time, data D(3) is transferred from the buffer of the driver to the buffer designated by the application task without going through the receiving window, as well. Due to this, compared with the conventional art, it is possible to decrease the number of times of data transfer. Furthermore, if a receiving request is not issued from the application task by the preset time, data D(3) held in the buffer of the driver is transferred to the receiving window. Therefore, the probability that the buffer of the driver is occupied by data D(3) is decreased compared with a case where no time limitation is given. Due to this, even if an Ethernet which does not include TCP/IP packets is received or a plurality of application tasks are executed on the PDA and the respective application tasks communicate with the other device, then it is possible to decrease the probability that the Ethernet frame received by the network controller cannot be transferred to the buffer of the driver.

[**0139**] Seventh Embodiment

[**0140**] A PDA which includes a communication device according to the seventh embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[**0141**] Referring to **FIG. 27, a** program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 27**, the same processings as those in the flowchart shown in **FIG. 21** are denoted by the same step numbers, respectively. Processings therefor are the same, as well. These processings will not be, therefore, repeatedly described herein.

[**0142**] In **S500**, CPU **120** determines whether or not TCP/IP protocol processing task **124** has received a TCP receiving request from application task **126** and has not notified application task **126** of the completion of TCP receiving. If TCP/IP protocol processing task **124** has received a TCP receiving request from application task and has not notified application task **126** of the completion of TCP receiving ("YES" in **S500**), the processing proceeds to **S708**. If not ("NO" in **S500**), the processing proceeds to **S700**.

[**0143**] In **S700**, CPU **120** determines whether or not the number of pieces of TCP data held in the driver is not greater

than a preset number. If the number of pieces of TCP data held in the driver is not greater than a preset number ("YES" in **S700**), the processing proceeds to **S116**.. If not ("NO" in **S700**), the processing proceeds to **S704**.

[**0144**] In **S702**, CPU **120** updates the number of pieces of TCP data held in the buffer of the driver. Thereafter, the processing proceeds to **S118** and then to **S104**.

[**0145**] In **S704**, CPU **120** transfers the TCP data to the receiving window. In **S706**, CPU **120** updates receiving window management data. Thereafter, the processing proceeds to **S118** and then to **S104**.

[**0146**] In **S708**, CPU **120** performs a processing F.

[**0147**] Referring to **FIG. 28**, processing F in **S708** will be described. In the flowchart shown in **FIG. 28**, the same processings as those in the flowchart shown in **FIG. 22** are denoted by the same step numbers, respectively. Processings therefor are the same, as well. They will not be, therefore, repeatedly described herein in detail.

[**0148**] In **S730**, CPU **120** determines whether or not the number of pieces of TCP data held in the driver is not greater than the preset number. If the number of pieces of TCP data held in the driver is not greater than the preset number ("YES" in **S730**), the processing proceeds to **S636**. If not ("NO" in **S730**), the processing proceeds to **S734**.

[**0149**] In **S732**, CPU **120** updates the number of pieces of TCP data corresponding to the buffer of the driver. Thereafter, the processing proceeds to **S118**.

[**0150**] In **S734**, CPU **120** transfers the TCP data which has not been transferred, from the buffer of the driver to the receiving window. In **S736**, CPU **120** updates the receiving window management information. Thereafter, the processing proceeds to **S118**.

[**0151**] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowchart will be described. In this embodiment, as in the case of the sixth embodiment, the extracted TCP segment data is not transferred to the receiving window but to the buffer designated by the application task from the buffer of the driver. It is noted, however, that only the data which can be contained in the buffer designated by the application task is transferred and the other data is held in the buffer of the driver.

[**0152**] The data is held in the buffer of the driver under the condition that the time for which the data is held in the buffer of the driver is within the preset time as described in the sixth embodiment and under the condition, unlike the sixth embodiment, that the number of pieces of data held in the buffer of the driver is within a preset number ("YES" in **S700** and "YES" in **S730**). Since the operation of holding the data in the buffer of the driver based on the preset number is the same as that of the second embodiment, it will not be repeatedly described herein in detail.

[**0153**] As can be seen, according to the PDA including the communication device in this embodiment, in addition to the operation in the sixth embodiment, the number of pieces of data held in the buffer of the driver is limited to not greater than the preset number. Due to this, it is possible to secure the empty areas of the buffer of the driver by as much as the preset number of pieces of data. Therefore, even if an Ethernet frame which does not include TCP/IP packets is received or even if a plurality of application tasks are executed on the PDA and the respective application tasks communicate with other devices, it is possible to decrease the probability that the Ethernet frame received by the Ethernet controller cannot be transferred to the buffer of the driver.

[**0154**] Eighth Embodiment

[**0155**] A PDA which includes a communication device according to the eighth embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[**0156**] Referring to **FIG. 29, a** program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 29**, the same processings as those in the flowchart shown in **FIG. 27** are denoted by the same step numbers, respectively. Processings therefore are the same, as well. These processings will not be, therefore, repeatedly described herein.

[**0157**] In **S500**, CPU **120** determines whether or not TCP/IP protocol processing task **124** has received a TCP receiving request from application task **126** and has not notified application task **126** of the completion of TCP receiving. If TCP/IP protocol processing task **124** has received a TCP receiving request from application task **126** and has not notified application task **126** of the completion of TCP receiving ("YES" in **S500**), the processing proceeds to **S802**. If not ("NO" in **S500**), the processing proceeds to **S700**.

[**0158**] In **S800**, CPU **120** compares a transmission order with the number of empty areas and determines whether or not the received TCP data can be held in the buffer of the driver. If the comparison between the transmission order and the number of empty areas shows that the TCP data can be held in the buffer of the driver ("YES" in **S800**), the processing proceeds to **S116**. If not ("NO" in **S800**), the processing proceeds to **S704**.

[**0159**] In **S802**, CPU **120** performs a processing G.

[**0160**] Referring to **FIG. 30**, processing G in **S802** will be described. In the flowchart shown in **FIG. 30**, the same processing as those in the flowchart shown in **FIG. 28** are denoted by the same step numbers, respectively. Processings therefore are the same, as well. These processing will not be, therefore, repeatedly described herein in detail.

[**0161**] In **S830**, CPU **120** compares a transmission order with the number of empty areas and determines whether or not the received data can be held in the buffer of the driver. If the comparison between the transmission order and the number of empty areas shows that the received data can be held in the buffer of the driver ("YES" in **S830**), the processing proceeds to **S636**. If not ("NO" in **S830**), the processing proceeds to **S734**. After the processings in **S636** and **S732**, the processing proceeds to **S118** and then returns to **S104**.

[**0162**] After the processings in **S734** and **S736**, the processing proceeds to **S118** and then to **S104**.

[0163] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described. In this embodiment, as in the case of the seventh embodiment, the extracted TCP segment data is not transferred to the receiving window but to the buffer designated by the application task **126** from the buffer of the driver. It is noted, however, that only the data which can be contained in the buffer designated by the application task **126** is transferred and the other data is held in the buffer of the driver. Here, the data which is held in the buffer of the driver is limited to the data which satisfies the two conditions, as described in the seventh embodiment, that the time for which the data is held in the buffer of the driver is within the preset time and that the number of pieces of data held in the buffer of the driver is within a preset number. In addition to the two conditions, the data which is held in the buffer of the driver is limited to the data which satisfies the condition, as in the case of the third embodiment, that data is in the order of transmission and within a range of the preset number ("YES" in **S700** and "YES" in **S800**). The other data is transferred from the buffer of the driver to the receiving window.

[0164] Since the conditions that only the data which is in the order of transmission from the transmission end device and within the preset number is held in the buffer of the driver are the same as those in the third embodiment, they will not be repeatedly described herein in detail.

[0165] As can be seen, according to the PDA including the communication device according to this embodiment, by limiting the number of pieces of data held in the buffer of the driver based on the order of transmission, it is possible to decrease the probability that the data is transferred to the receiving window after the preset time, compared with a case of limiting the number of pieces of data held in the buffer of the driver based on the order of receiving. As a result, it is possible to decrease the number of pieces of data transferred from the buffer of the driver to the receiving window and to decrease power consumption required for TCP protocol processings.

[0166] Ninth Embodiment

[0167] A PDA which includes a communication device according to the ninth embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein. Further, a program executed by the PDA including the communication device according to this embodiment has a control structure in which it is determined whether or not received data is to be held in the buffer of the driver based on a preset data size. Since the processings for determining whether or not the received data is to be held in the buffer of the driver based on the data size are the same as those in the fourth embodiment, they will not be repeatedly described herein in detail.

[0168] In the seventh and eighth embodiments, it is determined whether or not the received data is to be held in the buffer of the driver based on the number of pieces of data. In this embodiment, by contrast, it is determined whether or not the received data is to be held in the buffer of the driver based on the data size. By doing so, if the size of the received data is relatively small, it is possible to increase the number of empty areas of the buffer of the driver, compared with a case where the size of the received data is relatively large. As a result, compared with the PDA in the seventh and eighth embodiments, it is possible to further decrease the number of times of transferring the received data to the receiving window.

[0169] Tenth Embodiment

[0170] A PDA which includes a communication device according to the tenth embodiment will be described. In the first to ninth embodiments, the preset time, the preset number and the preset data size are constant values. In the communication device according to this embodiment, by contrast, these values can be set by the application task. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0171] Referring to **FIG. 31, a** program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 31**, the same processings as those in the flowchart shown in **FIG. 10** are denoted by the same step numbers, respectively. Processings therefor are the same, as well. These processings will not be, therefore, repeatedly described herein in detail.

[0172] After the processing in **S146**, CPU **120** performs a processing H in **S1000** and the processing then proceeds to **S104**.

[0173] Referring to **FIG. 32**, processing H in **S1000** will be described. In **S1030**, CPU **120** calculates a TCP receiving request interval as TCP receiving request interval=(present time)−(previous receiving request time). In **S1032**, CPU **120** performs an arithmetic operation of holding time update value=a×(TCP receiving request interval)/N. In **S1034**, if N is integrated by a preset number of times ("YES" in **S1034**), the processing proceeds to **S1036**. If not ("NO" in **S1034**), the processing proceeds to **S104**.

[0174] In **S1036**, CPU **120** updates preset time. The preset time is assumed as the update value calculated in **S1032**.

[0175] The operation of the PDA including the communication device according to this embodiment based on the above-mentioned structure and flowcharts will be described.

[0176] The PDA calculates an average of values obtained by multiplying the TCP receiving request interval by a coefficient ax in accordance with the intervals at which receiving requests are issued from application task **126** (in **S1032**). If the processing has been performed by a preset sample number (N) ("YES" in **S1034**), the preset time is updated to the calculated average (in **S1036**).

[0177] As can be seen, according to the PDA including the communication device according to this embodiment, the application task can dynamically change the preset time in accordance with the content of the processing of the application task. It is thereby possible to further decrease the number of times of transferring data from the buffer of the driver to the receiving window.

[0178] In this embodiment, description has been given while assuming that the preset time is updated. However, the present invention is not limited thereto. The preset number

of pieces of data and the preset data size may be also subjected to arithmetic operations by the application task so as to change the conditions for transferring the data from the buffer of the driver to the receiving window.

[0179] Eleventh Embodiment

[0180] A PDA which includes a communication device according to the eleventh embodiment will be described. The hardware configuration of the PDA according to this embodiment is the same as that of the PDA according to the first embodiment. The detailed description thereof will not be, therefore, repeatedly given herein.

[0181] The PDA including the communication device according to this embodiment can change the preset time, the preset number of pieces of data and the preset data size of the PDA according to the first to ninth embodiments, depending on the state of the network.

[0182] Referring to **FIG. 33, a** program executed by the PDA including the communication device according to this embodiment has the following control structure. In the flowchart shown in **FIG. 33**, the same processings as those in the flowchart shown in **FIG. 29** are denoted by the same step numbers, respectively. Processings therefore are the same, as well. These processings will not be, therefore, repeatedly described herein in detail.

[0183] If the result of the analysis of the TCP segment shows that TCP data is included, CPU **120** performs a processing I in **S1100**.

[0184] Referring to **FIG. 34**, processing I in **S1100** will be described. In **S1130**, CPU **120** determines whether or not a response number in a TCP header has been updated. The response number in the TCP header indicates that there is a response to transmitted TCP data. If the response number in a TCP header has been updated ("YES" in **S1130**), the processing proceeds to **S1132**. If not ("NO" in **S1130**), the processing proceeds to **S500**.

[0185] In **S1132**, CPU **120** measures round-trip transmission time from the response to the transmitted TCP data. Here, the round-trip transmission time is measured as round-trip transmission time=(present time)−(transmission time). In **S1134**, CPU **120** performs an arithmetic operation of update value=β×(round-trip transmission time)/M. In **S1136**, CPU **120** determines whether or not M is integrated by a preset number of times. If M is integrated by a preset number of times ("YES" in **S1136**), the processing proceeds to **S1138**. If not ("NO" in **S1136**), the processing proceeds to **S500**.

[0186] In **S1138**, CPU **120** updates the preset time. Here, the preset time is set at the update value calculated in **S1134**. Thereafter, the processing proceeds to **S500**,

[0187] The operation of the PDA which includes the communication device according to this embodiment based on the above-mentioned structure and the flowcharts will be described.

[0188] The PDA regularly measures data transmission time for transmitting data from the transmission end to the receiving end (in **S1132**). An average of values obtained by multiplying the measured transmission time by a coefficient β is calculated as the update value (in **S1134**). If the transmission time is relatively long, the interval at which the data is transmitted from the transmission end to the receiving end is long. Therefore, the preset time is set long (in **S1138**). If the transmission time becomes short depending on the state of the network, the interval at which the data is transmitted from the transmission end to the receiving end is short. Therefore, the preset time is set short (in **S1138**).

[0189] As mentioned so far, the PDA which includes the communication device according to this embodiment can change the setting of time for which the data is held in the buffer of the driver depending on the state of the network (transmission time on the network). It is thereby possible to appropriately change conditions for transferring the data from the buffer of the driver to the receiving window depending on the communication state of the network and to decrease the number of times of transferring the data from the driver to the receiving window depending on the state of the network.

[0190] In this embodiment, description has been given while assuming that the condition changed depending on the state of the network is the preset time. However, the present invention is not limited thereto. The preset number of pieces of data and the preset data size may be changed according to the state of the network (data transmission time).

[0191] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

What is claimed is:

1. A communication device comprising:

a network control circuit controlling transmission and reception of a data item for a network;

a first storage circuit connected to said network control circuit, and temporarily storing the received data item;

a second storage circuit connected to said first storage circuit, and storing data item; and

a control circuit controlling said data items stored in said first storage circuit and said second storage circuit to be transferred to a predetermined buffer, wherein

said control circuit includes:

a first transfer control circuit controlling said first storage circuit to transfer said data item stored in said first storage circuit to said buffer in response to a request to store data in said buffer, when the request is issued before preset time passes since said data item has been stored in said first storage circuit; and

a second transfer control circuit controlling said second storage circuit to transfer said data item stored in said first storage circuit to said second storage circuit when the preset time passes since said data item has been stored in said first storage circuit, and to transfer said data item stored in said second storage circuit to said buffer in response to the request to store data in said buffer.

2. The communication device according to claim 1, wherein

said first transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said buffer in response to the request issued before the preset time passes since said data item has been stored in said first storage circuit, until a preset number of data items have been stored in said first storage circuit, and

said second transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said second storage circuit if one of a condition that preset time passes since said data item has been stored in said first storage circuit and a condition that the preset number of data items have been stored in said first storage circuit is satisfied.

3. The communication device according to claim 2, wherein

said first transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said buffer in response to the request issued before the preset time passes since said data item has been stored in said first storage circuit, until the preset number of data items have been stored in said first storage circuit in accordance with an order of transmission of said data items to said first storage circuit.

4. The communication device according to claim 1, wherein

said first transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said buffer in response to the request issued before preset time passes since said data item has been stored in said first storage circuit, until a preset capacity of data items have been stored in said first storage circuit, and

said second transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said second storage circuit if one of a condition that the preset time passes since said data item has been stored in said first storage circuit and a condition that the preset capacity of data items have been stored in said first storage circuit is satisfied.

5. The communication device according to claim 4, wherein

said first transfer control circuit includes a circuit transferring said data item stored in said first storage circuit to said buffer in response to the request issued before the preset time passes since said data item has been stored in said first storage circuit, until the preset capacity of the data items have been stored in said first storage circuit in accordance with an order of transmission of said data items to said first storage circuit.

6. The communication device according to claim 1, wherein

said control circuit further includes a third transfer control circuit controlling said first storage circuit to transfer said data item stored in said first storage circuit to said buffer in response to the request, when the request is issued before said data item is stored in said first storage circuit.

7. The communication device according to claim 6, wherein

the request includes information indicating a transfer capacity of the data items transferred from said first storage circuit to said buffer, and

said third control circuit includes a circuit controlling said first storage circuit to transfer the data items not larger than said transfer capacity out of said data items stored in said first storage circuit to said buffer in response to the request issued before said data item is stored in said first storage unit, and to store the data items exceeding said transfer capacity in said first storage circuit.

8. The communication device according to claim 1, wherein

said preset time is set based on a signal from a transmitting end of the request to store data in said buffer.

9. The communication device according to claim 8, wherein

said preset time is set based on a frequency of the request transmitted from the transmission end.

10. The communication device according to claim 2, wherein

said preset number is set based on a signal from a transmission end of the request to store data in said buffer.

11. The communication device according to claim 4, wherein

said preset capacity is set based on a signal from a transmission end of the request to store data in said buffer.

12. The communication device according to claim 1, wherein

said preset time is set based on a communication state of said network.

13. The communication device according to claim 12, wherein

said preset time is set based on transmission time required for transmitting the data to said communication device on said network.

14. The communication device according to claim 2, wherein

said preset number is set based on a communication state of said network.

15. The communication device according to claim 4, wherein

said preset capacity is set based on a communication state of said network.

* * * * *